

# The Galactic O-Star Spectroscopic Survey (GOSSS).

## III. 142 additional O-type systems<sup>1</sup>

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### ABSTRACT

This is the third installment of GOSSS, a massive spectroscopic survey of Galactic O stars, based on new homogeneous, high signal-to-noise ratio,  $R \sim 2500$  digital observations selected from the Galactic O-Star Catalog (GOSC). In this paper we present 142 additional stellar systems with O stars from both hemispheres, bringing the total of O-type systems published within the project to 590. Among the new objects there are 20 new O stars. We also identify 11 new double-lined spectroscopic binaries (SB2s), of which 6 are of O+O type and 5 of O+B type, and an additional new triple-lined spectroscopic binary (SB3) of O+O+B type. We also revise some of the previous GOSSS classifications, present some egregious examples of stars erroneously classified as O-type in the past, introduce the use of luminosity class IV at spectral types O4-O5.5, and adapt the classification scheme to the work of Arias et al. (2016).

*Subject headings:* binaries:spectroscopic — binaries:visual — stars:early type — stars:emission line,Be — surveys

<sup>1</sup>The GOSSS spectroscopic data in this article were gathered with five facilities: the 1.5 m Telescope at the Observatorio de Sierra Nevada (OSN), the 2.5 m du Pont Telescope at Las Campanas Observatory (LCO), the 3.5 m Telescope at Calar Alto Observatory (CAHA), and the 4.2 m

William Herschel Telescope (WHT) and 10.4 m Gran Telescopio Canarias (GTC) at Observatorio del Roque de los Muchachos (ORM).

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## 1. Introduction

The Galactic O-Star Spectroscopic Survey (GOSSS) is a long-term project that is obtaining homogeneous, high SNR,  $R \sim 2500$ , blue-violet spectra of a large number (1000+) of O stars in the Milky Way and deriving accurate and self-consistent spectral types for all of them (Maíz Apellániz et al. 2011). In Sota et al. (2011), from now on paper I, we presented the first installment of the survey, which was comprised of the results for 178 northern ( $\delta > -20^\circ$ ) O stars. In Sota et al. (2014), from now on paper II, we extended the sample to the southern hemisphere for a total of 448 O stars. Papers I and II concentrated on the brightest O stars with the aim of achieving completeness down to  $B = 8$  but they also included many dimmer stars. This third paper continues the previous work by adding 142 new stars and raising the sample size to 590. Most of the new stars are of luminosity class V, which are relevant to the OVz phenomenon (Arias et al. 2016), but objects of other luminosity classes are also included.

This paper is organized as follows. We first present the changes in the observational setup and the classification scheme in section 2. Then, the spectral classifications are shown in section 3, divided in updates to O stars present in papers I and II, new O stars, and late-type stars previously misclassified as of O type. Finally, in section 4 we analyze the status of the project based on the new spectral classifications.

## 2. Data and methods

### 2.1. Blue-violet spectroscopy with $R \sim 2500$

The GOSSS data were described in papers I and II and the reader is referred there for further information. Here we detail the changes from those previous works.

Most of the spectra presented in paper I were obtained with the Albireo (Observatorio de Sierra Nevada - OSN - 1.5 m telescope) and TWIN (Calar Alto - CAHA - 3.5 m telescope) spectrographs. On the other hand, most of the spectra in paper II were obtained with the Boller & Chivens spectro-

graph at the Las Campanas (LCO) 2.5 m du Pont telescope). Starting with paper II, some spectra were also obtained with the ISIS spectrograph at the 4.2 m William Herschel Telescope (WHT) at the Observatorio del Roque de los Muchachos (ORM) in La Palma, Spain. In this paper we use data from all of the above instruments and we also add a new one, OSIRIS, at the 10.4 m Gran Telescopio Canarias (GTC) at the ORM (Table 1). Only a few GTC spectra are used here but the number will increase in future GOSSS papers, as we have already acquired data for over 200 stars, most of them too dim to be accessible with the other telescopes mentioned above. One difference between the GTC setup and the rest is that we use two volume-phased holographic gratings, R2500U and R2500V, allowing us to cover a larger wavelength range than with the other instruments. The exposures for the two gratings are taken consecutively, with the time difference between the first one and the last one being always less than one hour in order to avoid changes in the phase of rapidly moving spectroscopic binaries. As we do with the rest of the spectrographs, we use checks to compare that the quality of the data from all the spectrographs is uniform and, in those cases where the spectral resolution is higher than 2500, we degrade it to that value.

We have also started taking GOSSS data with [a] the GMOS spectrograph at the 8.1 m Gemini South telescope, [b] the Goodman High Throughput Spectrograph at the 4.1 m SOAR Telescope (both at Cerro Pachón, Chile), and [c] FRODOspec at the 2.0 m Liverpool Telescope (at the ORM) but we do not use them in this paper; their first GOSSS spectra will likely appear in a future paper IV.

The GOSSS data in this paper were obtained between 2007 and 2015. The OSN and LCO observations were obtained in visitor mode, the GTC observations in service mode, and the CAHA observations in a combination of both. For some SB2 and SB3 spectroscopic binaries, multiple epochs were obtained to observe the different orbit phases. In cases with known orbits, observations near quadrature were attempted.

The spectral classifications which are the main content of this paper are presented in Tables 4, 5, and 6 and they were obtained with MGB Maíz Apellániz et al. (2012, 2015c).

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Table 1: Telescopes, instruments, and settings used in this paper.

Telescope	Spectrograph	Grating	Spectral scale (Å/px)	Spatial scale ("/px)	Wav. range (Å)
LCO 2.5 m (du Pont)	Boller & Chivens	1200	0.80	0.71	3900–5500
OSN 1.5 m	Albireo	1800	0.62	0.83	3750–5070
CAHA 3.5 m	TWIN (blue arm)	1200	0.55	0.58	3930–5020
ORM 4.2 m (WHT)	ISIS (blue arm)	600	0.44	0.20	3900–5600
ORM 10.4 m (GTC)	OSIRIS	2500U	0.62	0.25	3440–4610
		2500V	0.80	0.25	4500–6000

## 2.2. Cataloguing

The spectral types are available through the latest version (currently v3.2) of the Galactic O-Star Catalog (GOSC, Maíz Apellániz et al. 2004), accessible at <http://gosc.iaa.es>. Starting in version 3, the GOSSS spectral types are the default ones and the basis for the catalog selection, though older classifications and those obtained with high-resolution spectra are also kept as possible additional columns. *B*- and *J*-band photometry are also provided in GOSC for all stars<sup>1</sup>. The rectified GOSSS spectra can also be obtained from GOSC as FITS tables.

The previous version of GOSC (3.1.2) had only entries in the main catalog, the part corresponding to O stars. Versions 2.0-2.4 of GOSC (Sota et al. 2008) did include four supplements for WR and WR+O systems, other early-type stars, late-type stars, and extragalactic massive stars, respectively. Since here we are presenting some late-type stars (see below), we are reintroducing the third supplement in GOSC 3.2. In future papers, we plan to release GOSSS spectral types for the other three supplements and we will populate GOSC accordingly.

The GOSSS spectral types were first made available at GOSC in June 2013 as part of GOSSS Data Release 1.0 (GOSSS-DR1.0, Sota et al. 2013). Later changes led to Data Releases 1.1 (with the spectral types from Sota et al. 2014) and 1.1.1 (minor changes in August 2014). The addition of new spectral types and changes to previous ones presented here constitutes GOSSS-DR2.0.

<sup>1</sup>See Maíz Apellániz et al. (2013) for details, we use  $B_{\text{ap}}$  and  $J_{\text{ap}}$ , respectively, to refer to the photometry in GOSC, where “ap” refers to approximate and is intended to be significant only to one tenth of a magnitude.

## 2.3. Spectral classification methodology and the new standard grid

The spectral classification methodology was laid out in paper I and some changes were presented in paper II. Here we introduce two additional changes.

The first one concerns the OVz phenomenon, described in detail in Sabín-Sanjulián et al. (2014) and Arias et al. (2016). OVz stars have deep He II  $\lambda 4686$  absorption lines, likely caused primarily by their extreme youth, though additional factors may also play a role. In paper II, we defined the  $z$  ratio as:

$$z = \frac{\text{EW}(\text{He II } \lambda 4686)}{\text{Max}[\text{EW}(\text{He I } \lambda 4471), \text{EW}(\text{He II } \lambda 4542)]} \quad (1)$$

by measuring the equivalent widths of He I  $\lambda 4471$ , He II  $\lambda 4542$ , and He II  $\lambda 4686$  in our main-sequence standard stars and classified a star as OVz when  $z$  was greater than  $\sim 1.0$ . Arias et al. (2016) analyzed the OVz phenomenon and decided to raise the critical value of  $z$  to 1.1 to avoid the borderline, often unclear, cases. Here we adopt that criterion and reclassify some of the stars in papers I and II.

The second one concerns the range of spectral types for which luminosity class IV is defined. When the O-type luminosity classification was introduced and calibrated by Walborn (1971, 1972, 1973) only three classes (V, III, I) were defined for spectral types earlier than O6. The luminosity range is relatively small at those types, and there was concern about possible differences in the strong stellar winds unrelated to luminosity affecting the Of criteria at the earliest types. Nevertheless, bright giants (class II) and supergiant subcat-

egories (Ia, Iab, and Ib) were defined as early as types O6-O6.5, while Sota et al. (2011) extended the use of class IV as well to those types in the larger, higher quality GOSSS sample. It is also relevant that subsequent UV work demonstrated a high degree of correlation (and, by implication, robustness) between the stellar-wind profiles and the optical spectral types throughout the entire O-type range (Walborn et al. 1985).

In the context of the quantification of the  $z$  ratio by Arias et al. (2016), we have become aware of several spectra classified as type V with excessively small values of the ratio, i.e. in the range 0.5-0.7. A number of them are of types O4-O5.5, and inspection from this viewpoint reveals Of morphologies in the GOSSS data well intermediate between most class V spectra and the class III standards, in terms of both the He II  $\lambda 4686$  absorption and N III  $\lambda 4634$ -41-42 emission strengths. Multiple observations of several of these spectra demonstrate robustness in these features. Hence we now define luminosity class IV at types O4-O5.5 to describe such spectra. In view of the strengths of the Of features in most of them, we adopt the (f)-parameter for them, as opposed to ((f)) for class IV at types O6 and later. We also note that HD 93 250 AB was previously assigned to class III by Sota et al. (2014), whereas it is clearly more similar to the other class IV objects; originally it had been classified as V. Thus, this classification enhancement improves the consistency of the luminosity classification at these types.

Calibration work to determine whether this classification development corresponds to a consistent luminosity difference remains for the future, likely depending upon Gaia (Perryman et al. 2001) measurements for reliable results. However, regardless of how that turns out, the development provides a more precise systematic description of the spectra themselves.

The two changes above (the critical value for the OVz phenomenon and the definition of luminosity class IV for O4-O5.5 stars) imply updates on the standard grid used for spectral classification. The first GOSSS-based standard grid (OB2500 v1.0) was presented in Sota et al. (2011) and the second one (OB2500 v2.0), which filled some gaps, in Maíz Apellániz et al. (2015c). Here we present OB2500 v3.0 in Table 2, with an additional column for OVz standards and some gaps in

the grid filled with respect to the previous version. We plan to keep filling those gaps when we find additional appropriate stars within our survey. Note that most of the gaps occur at the earliest types (O5.5 and earlier for the III to Vz columns, O7.5 and earlier for the supergiants), which is expected given the scarcity of those types in the solar neighborhood. One possibility we will consider in the future is the use of LMC O stars.

### 3. Results

This section constitutes the main body of the paper, the spectral classifications, and is divided in three parts. First, we revise some of the results from papers I and II. Second, we present new spectral classifications for O stars not included in those papers. Third, we show some cases previously classified in the literature or in Simbad as being O stars which turn out to be of late type. The information is given in Tables 4, 5, and 6, with details about each star (sorted by GOS ID within each subsection) provided in the text.

#### 3.1. Stellar systems from papers I and II

##### 3.1.1. Name changes due to the discovery of companions

In the last two years, several papers have used high-spatial resolution techniques to detect new bright visual close companions to stars present in papers I and II. The proximity of those companions (with separations of tens of milliarcseconds or less) do not allow us to obtain separate GOSSS spectra for them but the nomenclature used in GOSSS (a companion must be included in the star name if it contributes a significant fraction of light to the blue-violet spectrum, established as  $\Delta B \leq 2.0$ ) makes us change the name of the star from the one listed in our previous papers. The name changes are given in Table 3, where no spectral types are listed since they remain unchanged unless the system is also listed in the next subsubsection. Table 3 gives the current GOSSS name (with all the currently known bright components included in the Washington Double Star Catalog, WDS, Mason et al. 2001), the GOSSS ID, the reference, the new component, and possibly a comment. Note that most of the new components are from Sana et al. (2014).

Table 2: The OB2500 v3.0 grid of classification standards.

	Vz	V	IV	III	II	Ib	Iab/I	Ia
O2							<i>HD 93129 AaAb</i>	
O3	<i>HD 64 568</i>	...		...			Cyg OB2-7	
O3.5	<i>HD 93 128</i>	...		<i>Pismis 24-17</i>			<i>NGC 3603 HST-48</i>	
O4	<i>HD 96 715</i>	<b>HD 46 223</b>	<b>HD 168 076 AB</b> <i>HD 93 250 AB</i>	...			HD 15 570 HD 16 691 HD 190 429 A	
O4.5	...	HD 15 629 <i>HDE 303 308 AB</i>	HD 193 682	...			HD 14 947 Cyg OB2-9	
O5	<b>HD 46 150</b>	<i>HDE 319 699</i>	<b>HD 168 112 AB</b>	<i>HD 93 843</i>			<i>CPD -47 2963 AB</i>	
O5.5	...	<i>HD 93 204</i>	...	...			Cyg OB2-11 <i>ALS 18 747</i>	
O6	HD 42 088 <i>HDE 303 311</i>	<b>ALS 4880</b> <i>CPD -59 2600</i>	<i>HD 101 190 AaAb</i>	HDE 338 931	HDE 229 196	...	...	<b>HD 169 582</b>
O6.5	<i>HD 91 572</i>	<b>HD 167 633</b> HD 12 993	<i>HDE 322 417</i>	HD 190 864 HD 96 946 HD 152 723 AaAb HD 156 738 AB	<b>HD 157 857</b>	...	...	<i>HD 163 758</i>
O7	<i>HD 97 966</i> <i>CPD -58 2620</i> HDE 242 926 <i>HD 91 824</i>	<i>HD 93 146 A</i> <i>HD 93 222 AB</i>	ALS 12 320	Cyg OB2-4 A <i>HD 93 160 AB</i>	<i>HD 94 963</i> <i>HD 151 515</i>	<i>HD 69 464</i> HD 193 514	...	...
O7.5	<i>HD 152 590</i>	HD 35 619	<i>HD 97 319</i>	<i>HD 163 800</i>	HD 34 656 <b>HD 171 589</b>	HD 17 603 <i>HD 156 154</i>	HD 192 639 <b>9 Sge</b>	...
O8	<i>HDE 305 539</i> <i>HDE 305 438</i>	<i>HD 101 223</i> <i>HD 97 848</i> HD 191 978	<i>HD 94 024</i> <i>HD 135 591</i>	<i>HDE 319 702</i> <b><math>\lambda</math> Ori A</b>	<i>63 Oph</i>	<b>BD -11 4586</b>	HD 225 160	<i>HD 151 804</i>
O8.5		<i>HDE 298 429</i> HD 14 633 AaAb <b>HD 46 149</b> <i>HD 57 236</i> <i>Trumpler 14-9</i>	<b>HD 46 966 AaAb</b>	<i>HD 114 737 AB</i> HD 218 195 A	<i>HD 75 211</i> HD 207 198	<i>HD 125 241</i>	...	<i>HDE 303 492</i>
O9		10 Lac HD 216 898 <i>CPD -59 2551</i>	<i>HD 93 028</i> <i>CPD -41 7733</i>	<i>HD 93 249 A</i> HD 24 431	<i>HD 71 304</i> $\tau$ CMa AaAb	19 Cep	HD 202 124 <i>HD 152 249</i> HD 210 809	$\alpha$ Cam
O9.2		<b>HD 46 202</b> HD 12 323	<i>HD 96 622</i>	<i>CPD -35 2105 AaAbB</i> HD 16 832	ALS 11 761	<i>HD 76 968</i>	<i>HD 154 368</i> <i>HD 123 008</i> HD 218 915	<i>HD 152 424</i>
O9.5		AE Aur $\mu$ Col	HD 192 001 <i>HD 93 027</i> <i>HD 155 889 AB</i>	<i>HD 96 264</i>	<b><math>\delta</math> Ori AaAb</b>	...	HD 188 209	...
O9.7		<b><math>\nu</math> Ori</b>	HD 207 538	HD 189 957 <i>HD 154 643</i>	<i>HD 68 450</i> <i>HD 152 405</i> HD 10 125	<b>HD 47 432</b> <i>HD 154 811</i> <i>HD 152 147</i>	HD 225 146 $\mu$ Nor <i>HD 104 565</i> HD 191 781	HD 195 592 <i>GS Mus</i>

Notes Normal, *italic*, and **bold** typefaces are used for stars with  $\delta > +20^\circ$ ,  $\delta < -20^\circ$ , and the equatorial intermediate region, respectively.

### 3.1.2. Spectral type changes

In Table 4 we list the stellar systems already included in papers I and II for which we have obtained revised spectral types. They are ordered by GOSSS ID, which corresponds for practical purposes to an ordering by Galactic longitude  $l^2$ . The corresponding spectrograms are shown in the same order in Fig. 1. The majority of the systems in this section are included because of a change in the  $z$  suffix, as described in subsection 2.3. A minority are included due to the definition of luminosity class IV for types O4-O5.5 (see subsection 2.3) or the assignment of an SB2 status to the system in the GOSSS data that was not possible at the time of papers I and II. Since all of these systems have been already discussed in the previous GOSSS papers, we only present additional details about some of them in this section. In particular, we discuss several SB2 systems for which we have fine-tuned the spectral classification using the new standard grid.

**HD 165 052 = ALS 4635.** We have obtained observations at a new epoch for this SB2 that has allowed us to improve the classification of O5.5: Vz + O8: V of paper II to O6 Vz + O8 Vz. The system was caught at a velocity separation  $\Delta v$  between the two spectroscopic components of  $\sim 200$  km/s.

**HD 168 075 = NGC 6611-197.** We have obtained observations at a new epoch for this star and derived a spectral type of O6.5 V((f)), slightly earlier than the one in paper I. The change is not surprising, given that this object is an SB2 classified as O6.5 V((f)) + B0-1 V by Sana et al. (2009).

**HD 168 076 AB = ALS 4908 AB.** This system is one of the luminosity class IV standards due to the introduction of that class for the spectral subtypes O4-O5.5.

**HD 168 112 AB = ALS 4912 AB.** This star is one of the luminosity class IV standards due to the introduction of that class for the spectral subtypes O4-O5.5.

**HD 173 010 = BD -09 4805 = ALS 9901.** This object was classified as O9.7 Ia. Walborn et al. (2016) changed the luminosity class to Ia+ based on GOSSS data.

**HD 192 281 = V2011 Cyg = ALS 10 943.** This object is one of the new O4-O5.5 IV stars.

**HDE 229 232 AB = BD +38 4070 AB = ALS 11 296 AB.** This object has anomalous and broad line profiles, possibly originating in a companion. Note that Aldoretta et al. (2015) found a bright companion which is spatially unresolved in the GOSSS data, hence the AB component designation. Williams et al. (2013) identify this system as an SB1 with a preliminary period of 6.2 d.

The ((f)) suffix for this object was omitted by mistake in paper II.

**HD 14 434 = ALS 7124.** This star is one of the new O4-O5.5 IV stars.

**HD 48 099 = ALS 9098.** We have reanalyzed the data for this SB2 to change the classification of O5 V((f))z + O9: V of paper II to O5.5 V((f))z + O9 V. The system was caught at a  $\Delta v$  of  $\sim 140$  km/s.

**HD 92 206 C = CPD -57 3580 = ALS 1695.** We have reanalyzed the data for this SB2 to change the classification of O8 Vz + O9.7 V of paper II to O8 V(n)z + B0: V. The system was caught at a  $\Delta v$  of  $\sim 425$  km/s.

**ALS 15 204 = CPD -56 2608 A = Trumpler 14 MJ 92.** In paper II we identified this object as an O star for the first time and we hinted it may be an SB2. For this paper we obtained a new epoch and we indeed detect it is an SB2 caught with a  $\Delta v$  of  $\sim 150$  km/s (which is a low separation for GOSSS but it is possible because of the small magnitude difference between the two components and their low  $v \sin i$ ). The GOSSS spectral classification is O7.5 Vz + O9: V. We also placed ALS 15 203 (= CPD -56 2608 B), located 4''8 away, on the slit and found it is an early-B star.

<sup>2</sup>The only exceptions being systems with very similar values of  $l$ .

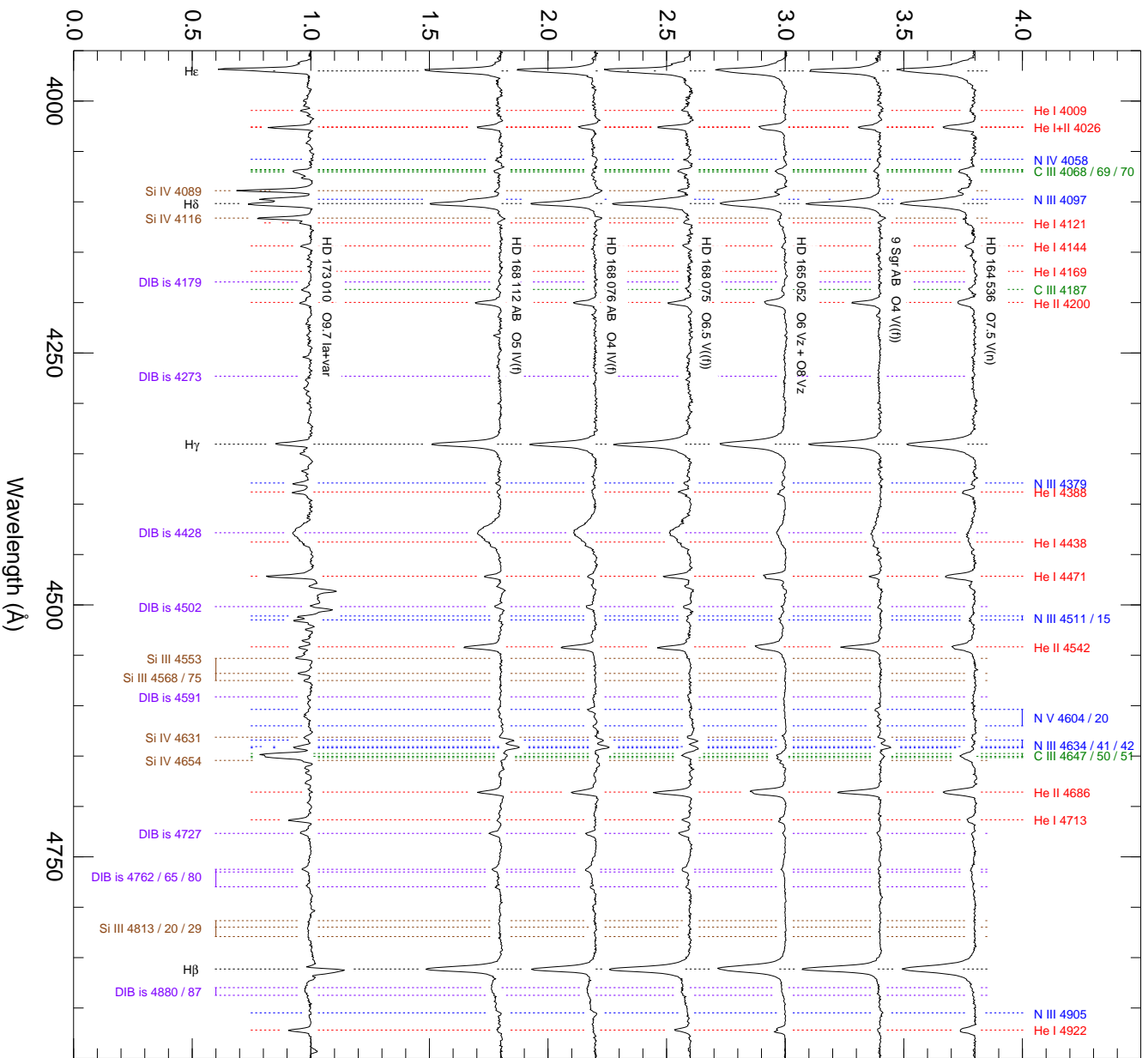


Fig. 1.— Spectrograms for stars already present in papers I and II. The targets are sorted by GOS ID.

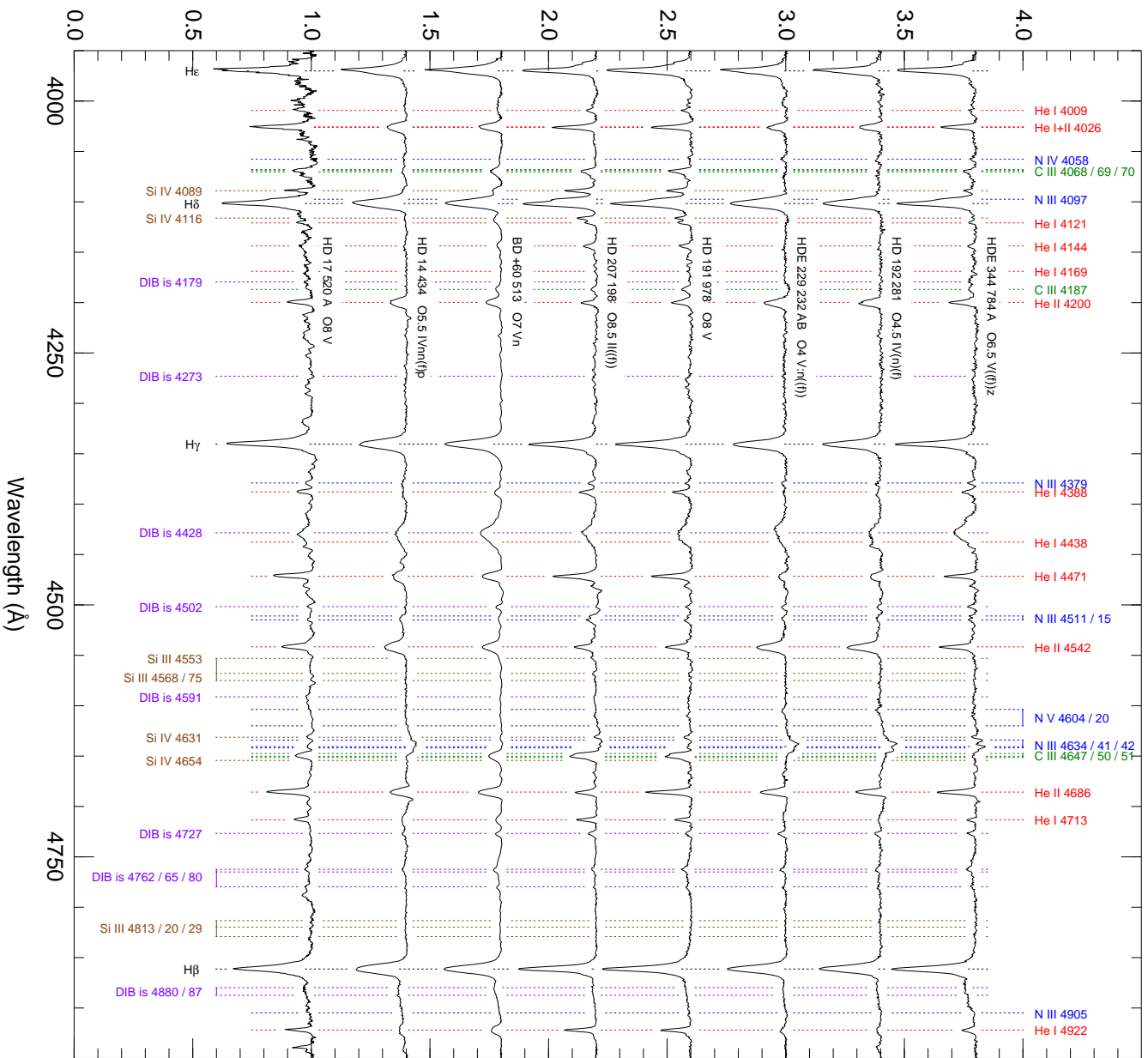


Fig. 1.— (continued).



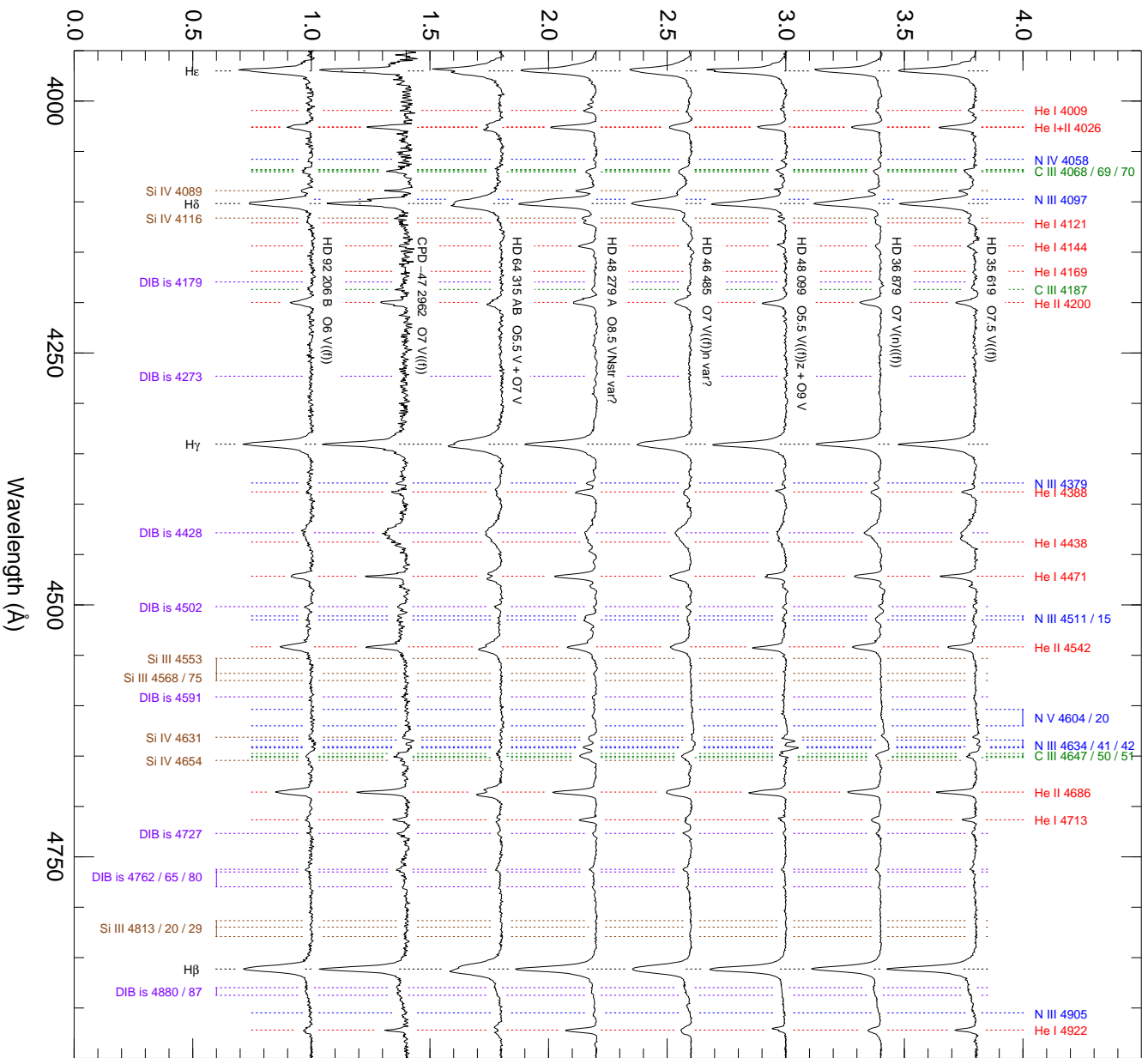


Fig. 1.— (continued).

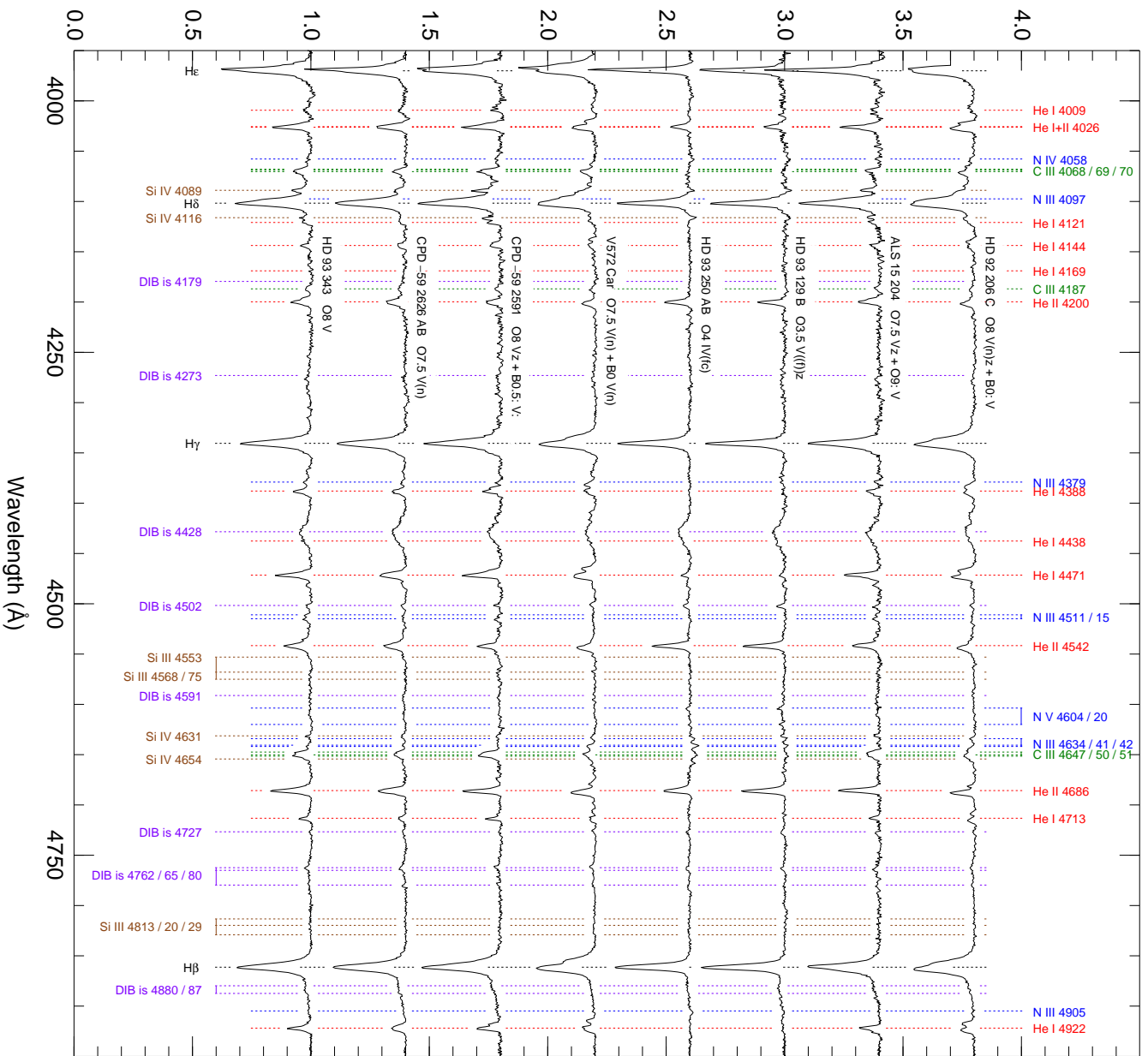


Fig. 1.— (continued).

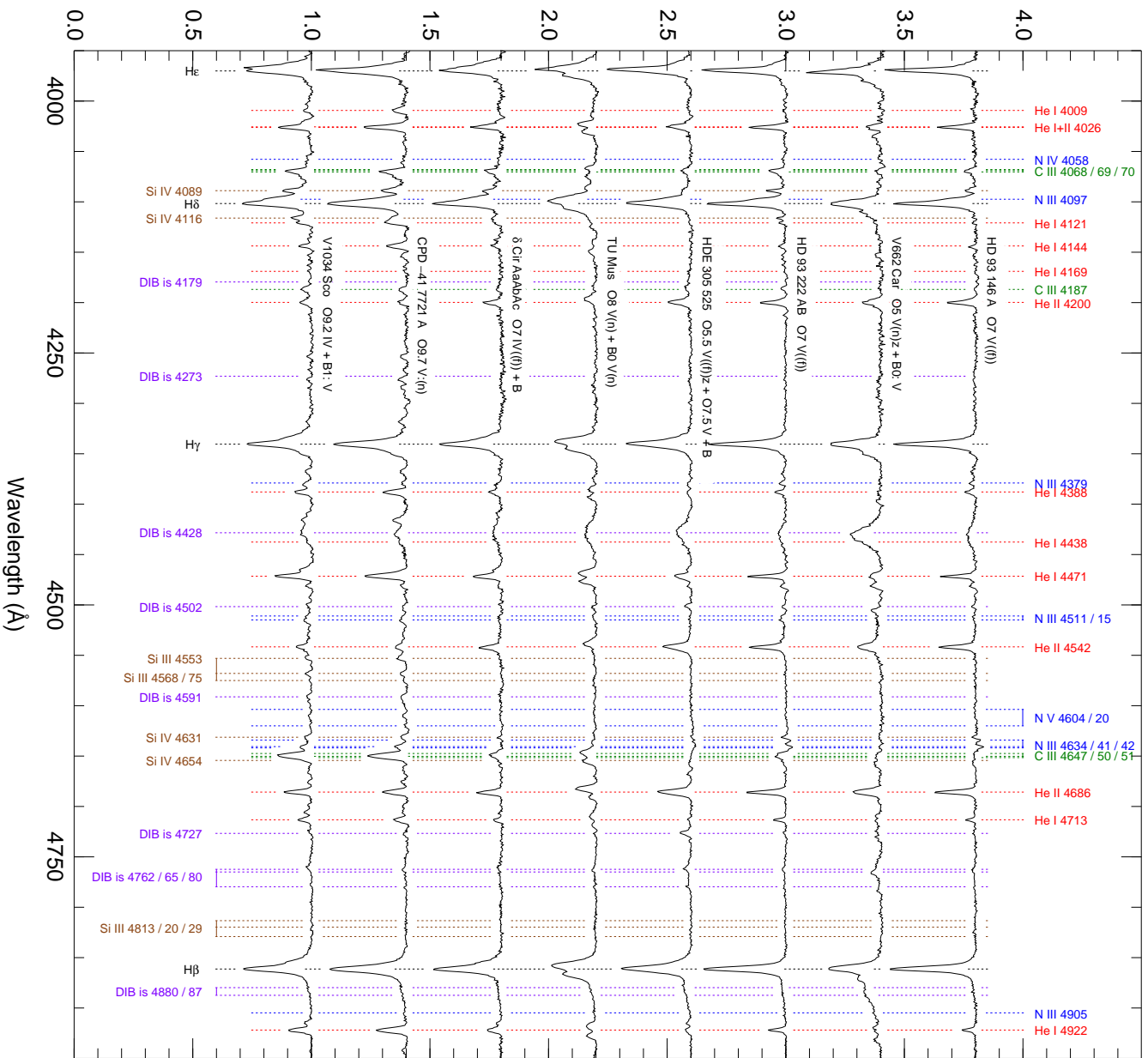


Fig. 1.— (continued).

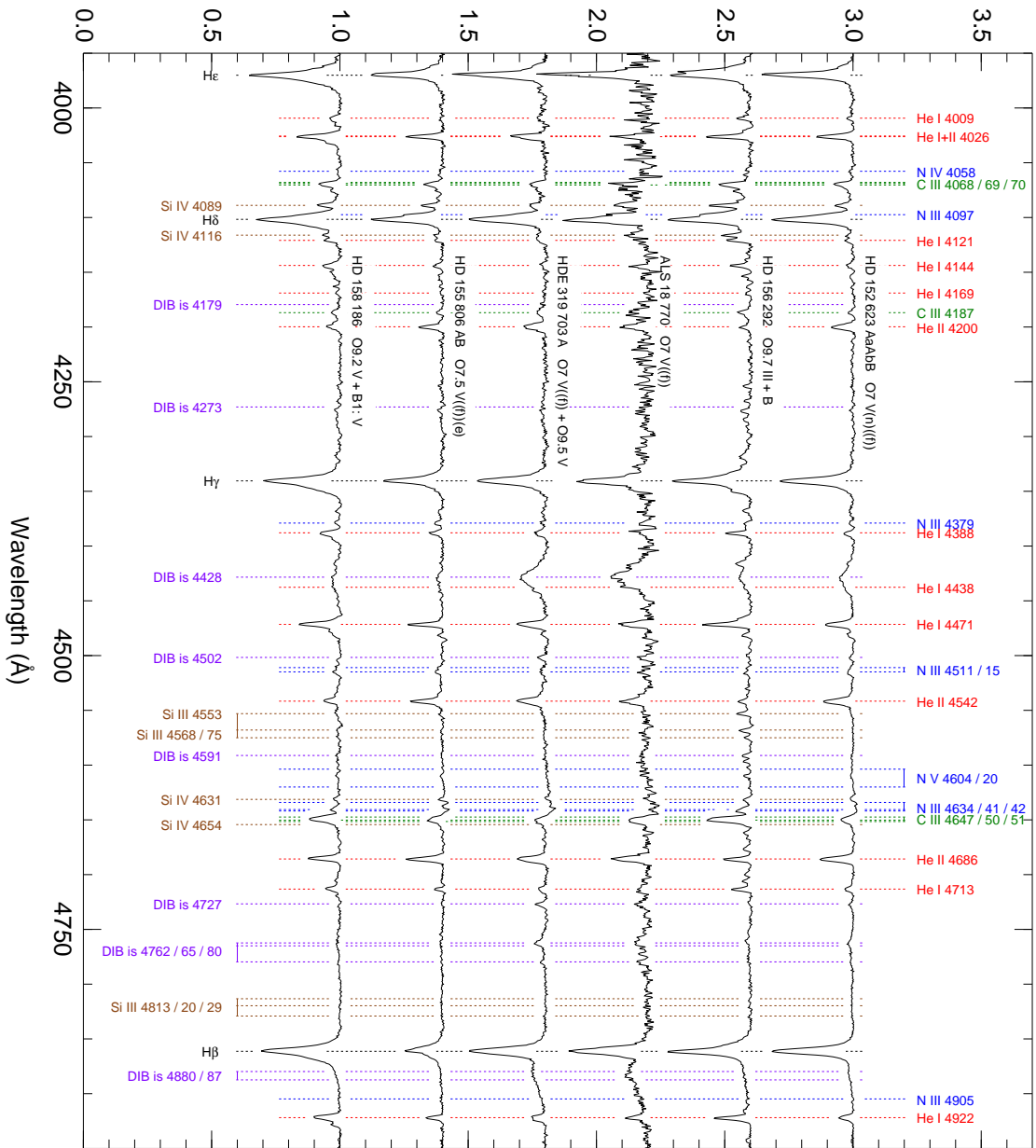


Fig. 1.— (continued).

**HD 93 250 AB = ALS 1859 AB.** This object is one of the new O4-O5.5 IV stars.

**CPD -59 2591 = Trumpler 16-21 = ALS 15 217.**

We have reanalyzed the data for this SB2 to change the classification of O8.5 V + B0.5: V: of paper II to O8 Vz + B0.5: V:. The system was caught at a  $\Delta v$  of  $\sim 200$  km/s.

**V662 Car = FO 15 = ALS 16 081.** We have reanalyzed the data for this SB2 to change the classification of O5 Vz + B0: V of paper II to O5 V(n)z + B0: V:. The system was caught at a  $\Delta v$  of  $\sim 625$  km/s.

**HDE 305 525.** In paper II we classified this object as O5.5 V(n)((f))z, that is, with broad lines but without identifying it as a spectroscopic binary. A reanalysis of the data allowed us to discover that [a] the broad lines were caused by another O star blueshifted by  $\sim 175$  km/s and [b] the HeI lines (but not the HeII ones) had a third absorption component redshifted by  $\sim 400$  km/s, indicating the presence of a B star as an additional spectroscopic component. Therefore, we classify this is a new SB3 system (the first one identified as such with GOSSS) with spectral types O5.5 V((f))z + O7.5 V + B. A revision of OWN data confirms the SB3 nature, as it appears that way in at least one epoch. We looked at the ASAS All-Star Catalogue (<http://www.astrouw.edu.pl/asas/?page=aasc>) and we identified HDE 305 525 as an eclipsing binary with a 1.9018 d period.

**$\delta$  Cir AaAbAc = HD 135 240 AaAbAc = ALS 3331 AaAbAc.** In paper II we did not detect double lines in this object in the GOSSS spectra, even though it is an SB3 system (Penny et al. 2001), who classified it as O7 III-V + O9.5 V + B0.5 V. A reanalysis of the data with MGB has allowed us to classify it as an SB2 with O7 IV((f)) + B, which is consistent with the Penny et al. (2001) result considering that we see only two components and they detect three. The system was caught at a  $\Delta v$  of  $\sim 300$  km/s. In the component nomenclature AaAb corresponds to the inner, short period 3.9 d binary (though the system remains unresolved at the time of the

writing) while Ac is the third outer component resolved by Sana et al. (2014) with a period of 1644 d measured by Mayer et al. (2014).

**V1034 Sco = CPD -41 7742 = ALS 15 757.**

In paper II we did not detect double lines in this object in the GOSSS spectra, even though it is an SB2 system classified by Sana et al. (2008) as O9.5 V + B1.5 V. A reanalysis of the data with MGB has allowed us to classify it as an SB2 with O9.2 IV + B1: V, similar to the Sana et al. (2008) result. The system was caught at a  $\Delta v$  of  $\sim 450$  km/s.

**HD 156 292 = ALS 4055.** In paper II we did not detect the SB2 nature of this target in the GOSSS spectra, even though it is a system of that nature as revealed by OWN (Barbá et al. 2010). A reanalysis of the data with MGB has allowed us to derive an O9.7 III + B spectral classification with a  $\Delta v$  of  $\sim 350$  km/s.

**HDE 319 703 A = ALS 4081 A.** In paper II we did not detect the SB2 nature of this target in the GOSSS spectra, even though it is a system of that nature as revealed by OWN (Barbá et al. 2010). A reanalysis of the data with MGB has allowed us to derive an O7 V((f)) + O9.5 V spectral classification with a  $\Delta v$  of  $\sim 175$  km/s.

**HD 158 186 = V1081 Sco = ALS 4182.** In paper II we did not detect double lines in this target in the GOSSS spectra, even though it is an SB3 system as revealed by OWN (Barbá et al. 2010). A reanalysis of the data with MGB has allowed us to derive an SB2 O9.2 V + B1: V spectral classification with a  $\Delta v$  of  $\sim 375$  km/s.

### 3.2. New systems in GOSSS

In Table 5 we list the new O-type stellar systems incorporated into GOSSS in this paper, ordered by GOSSS ID. The corresponding spectrograms are shown in the same order in Fig. 2. We present here additional information about each one of the systems.

**ALS 19 618 = NGC 6618 Sch-1.** Crampton et al. (1978) classified this NGC 6618 star as O5 V. We obtain an earlier spectral type of O4 V(n)((fc)).

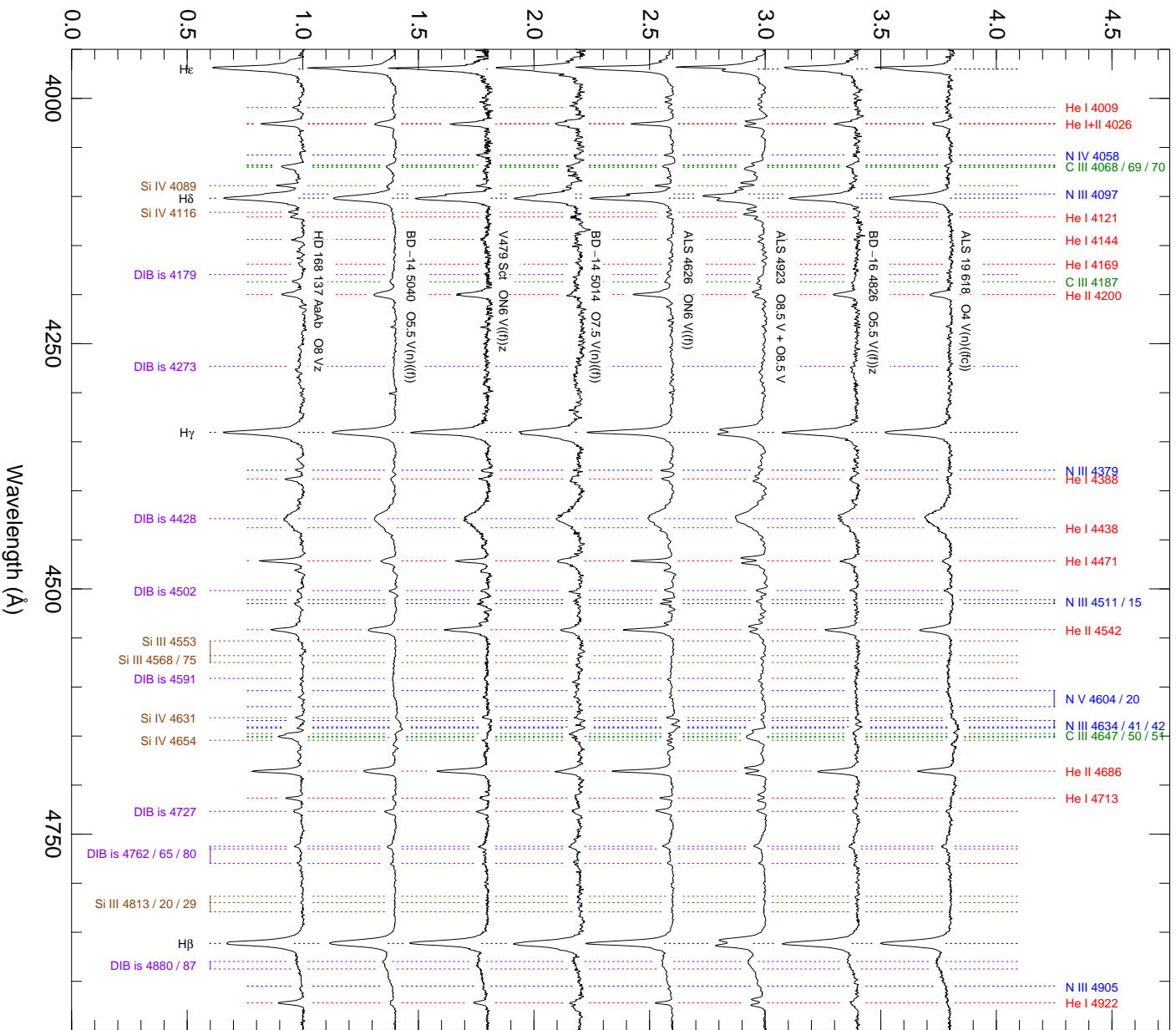


Fig. 2.— Spectrograms for new GOSSS stars. The targets are sorted by GOS ID. [See the electronic version of the journal for a color version of this figure.]

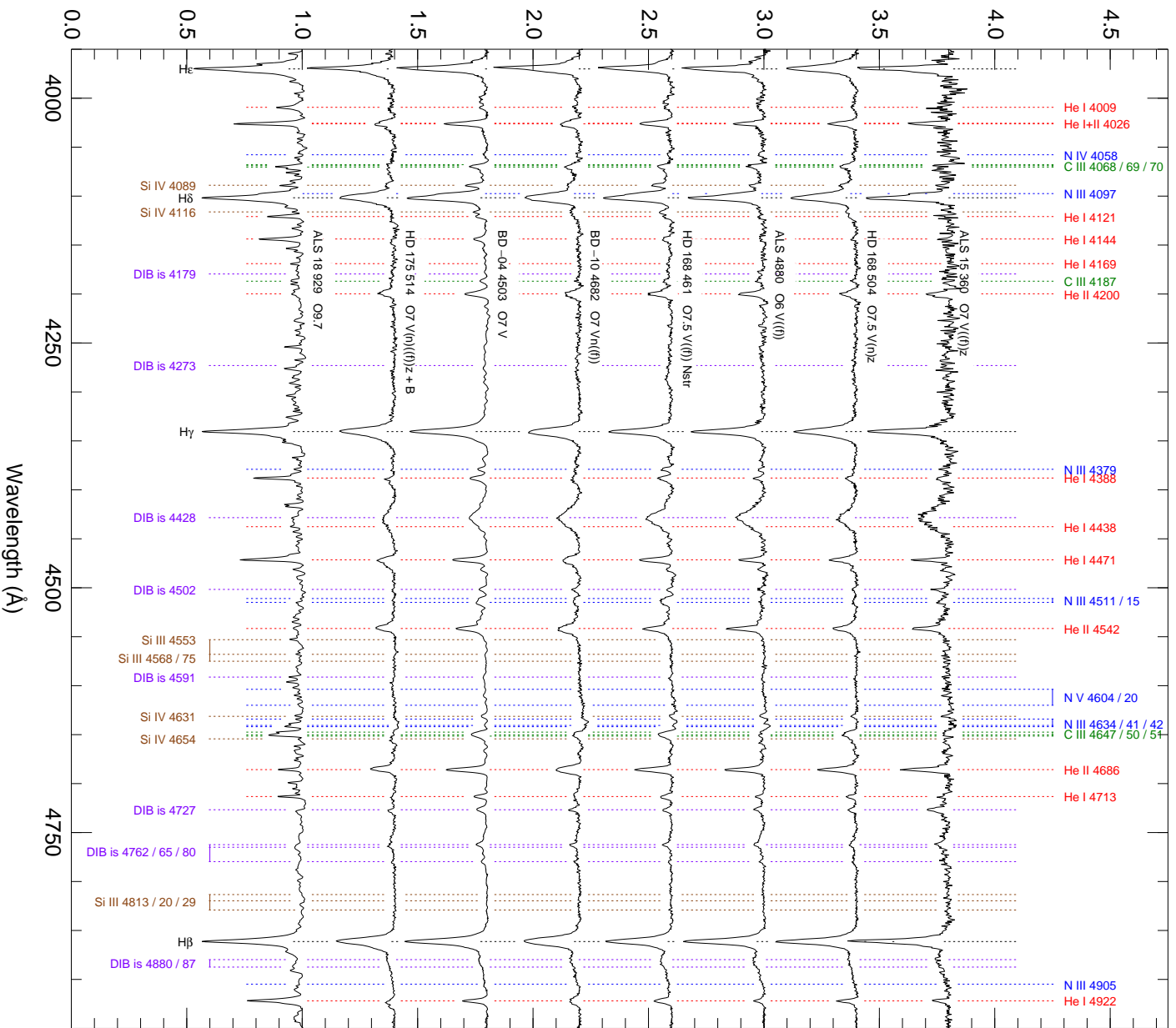


Fig. 2.— (continued).

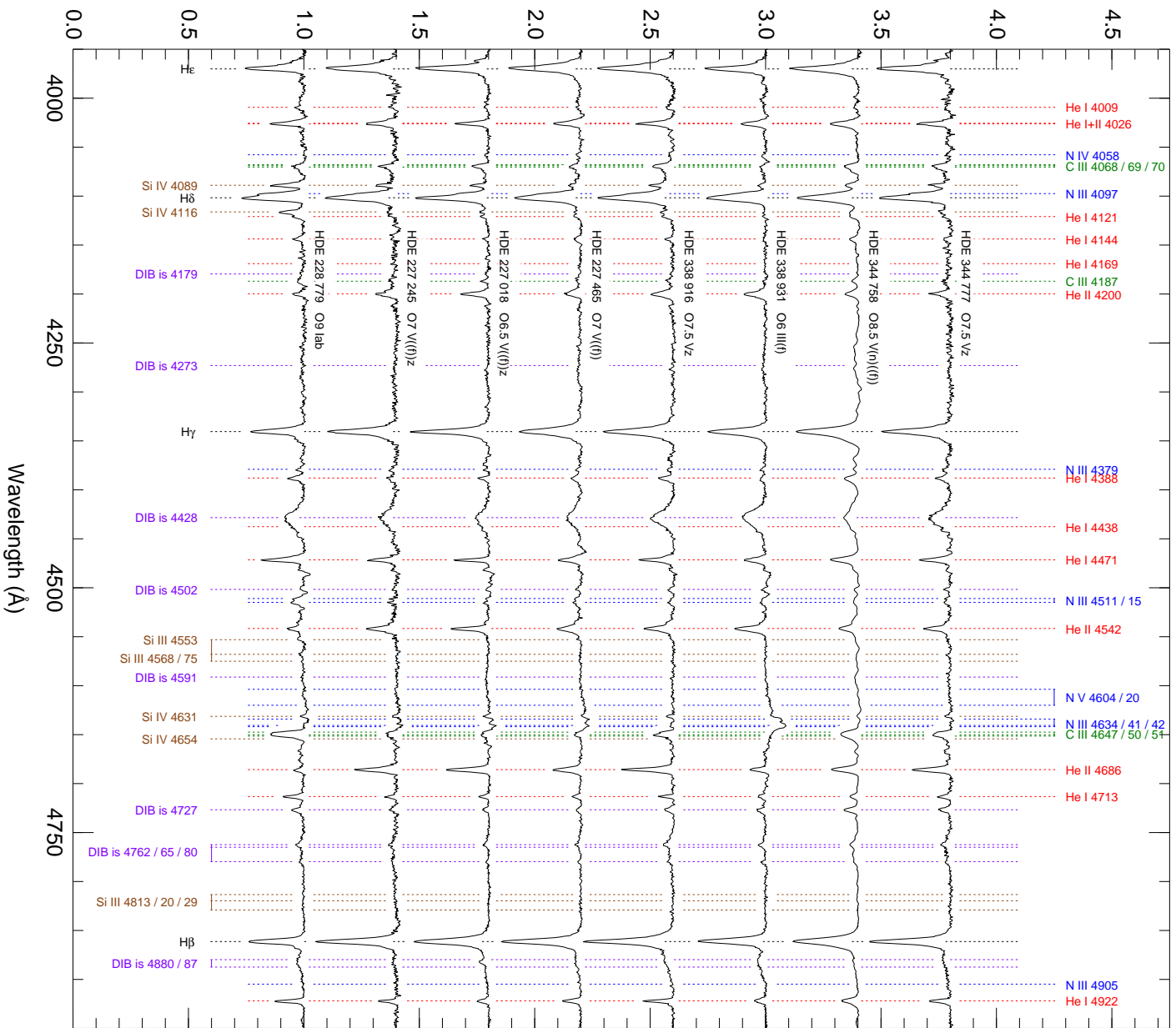


Fig. 2.— (continued).



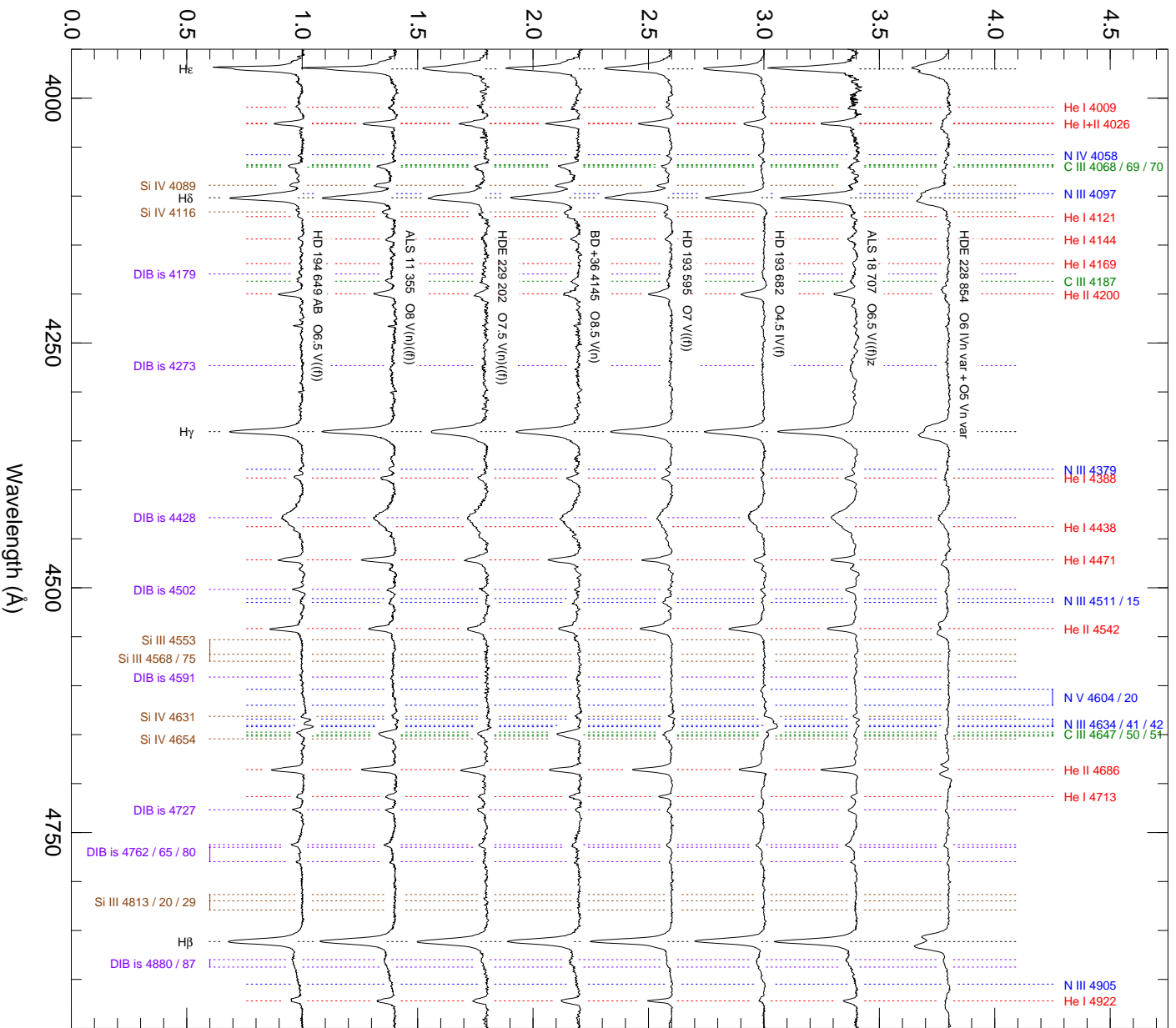


Fig. 2.— (continued).

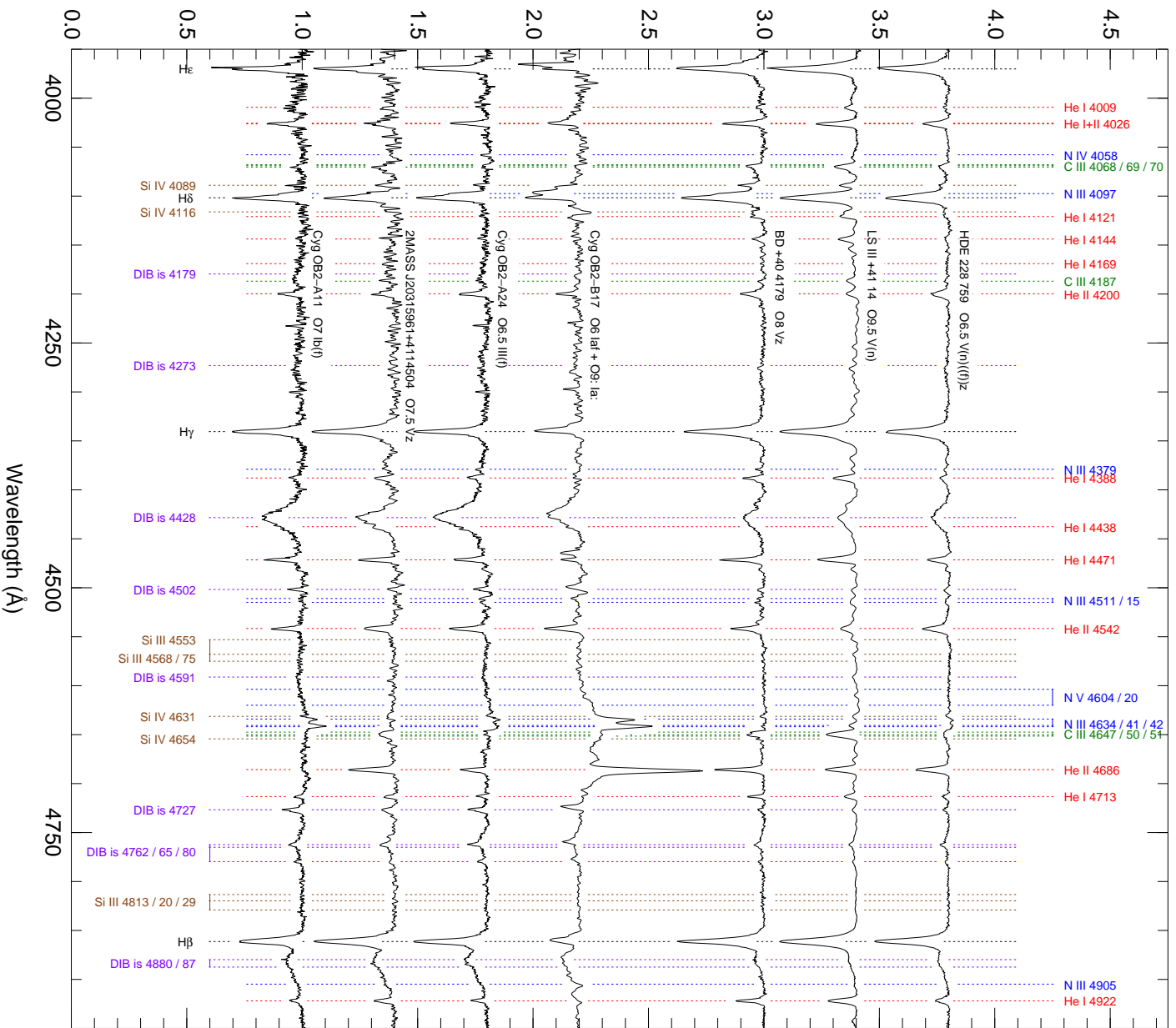


Fig. 2.— (continued).

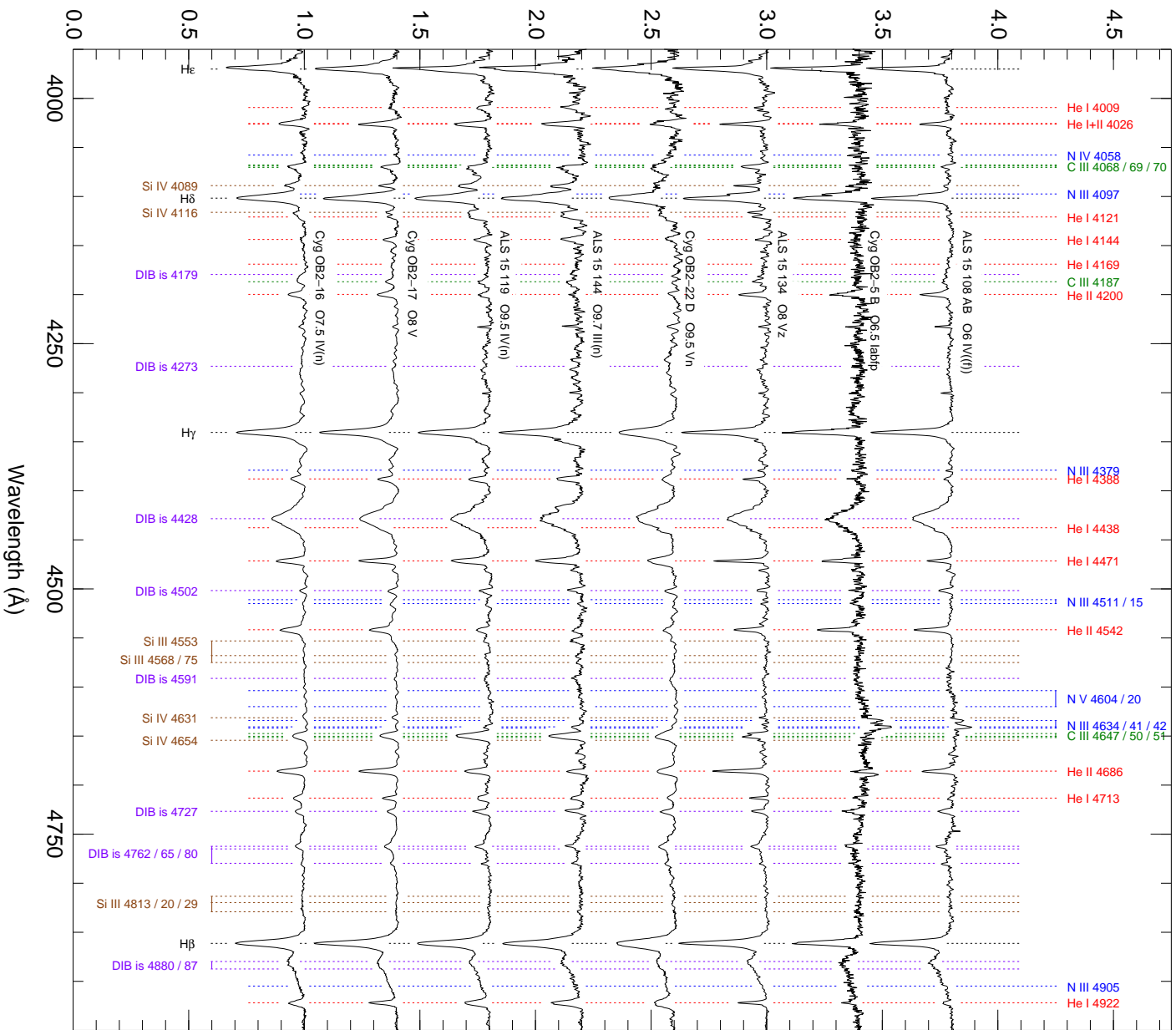


Fig. 2.— (continued).

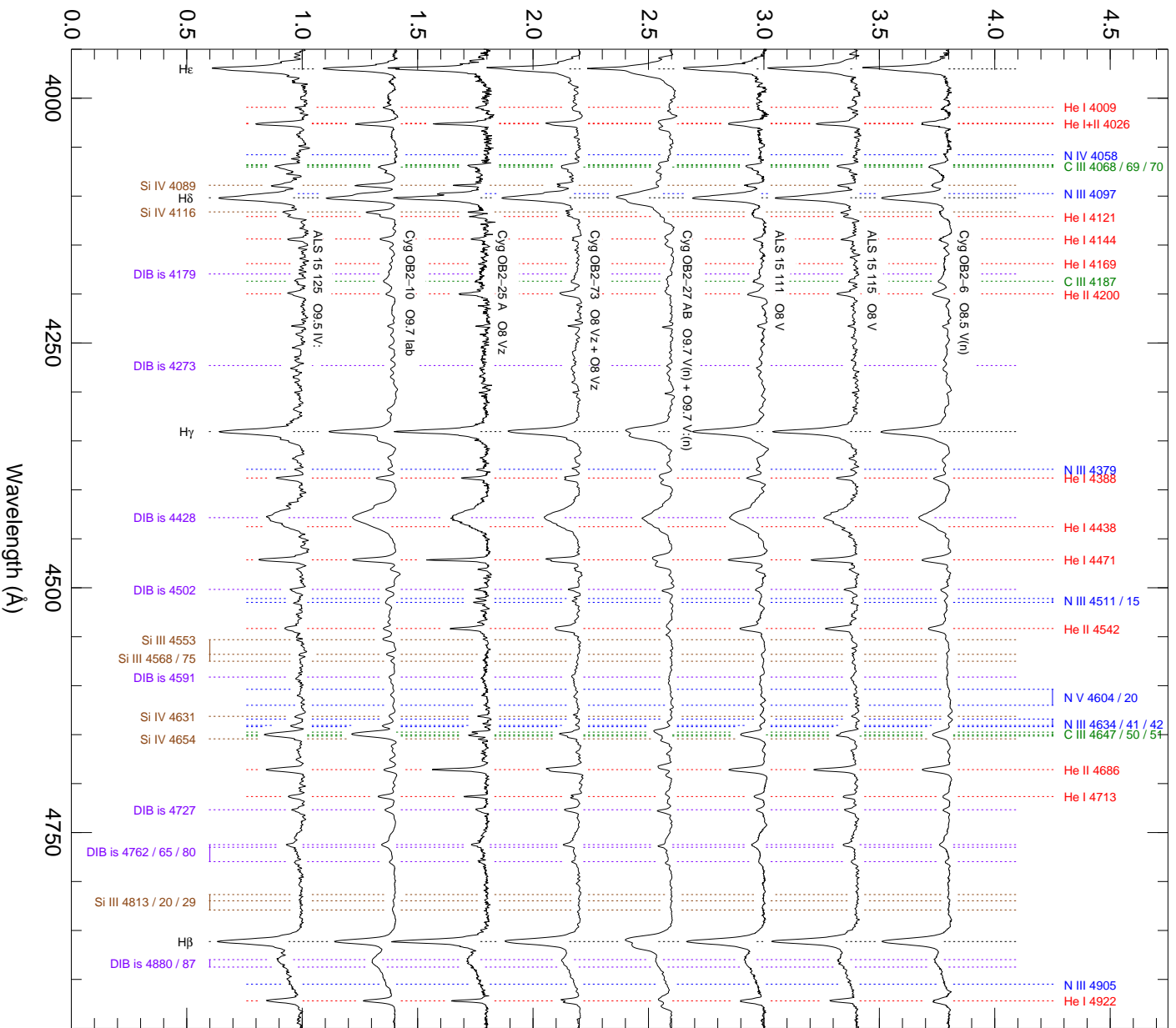


Fig. 2.— (continued).

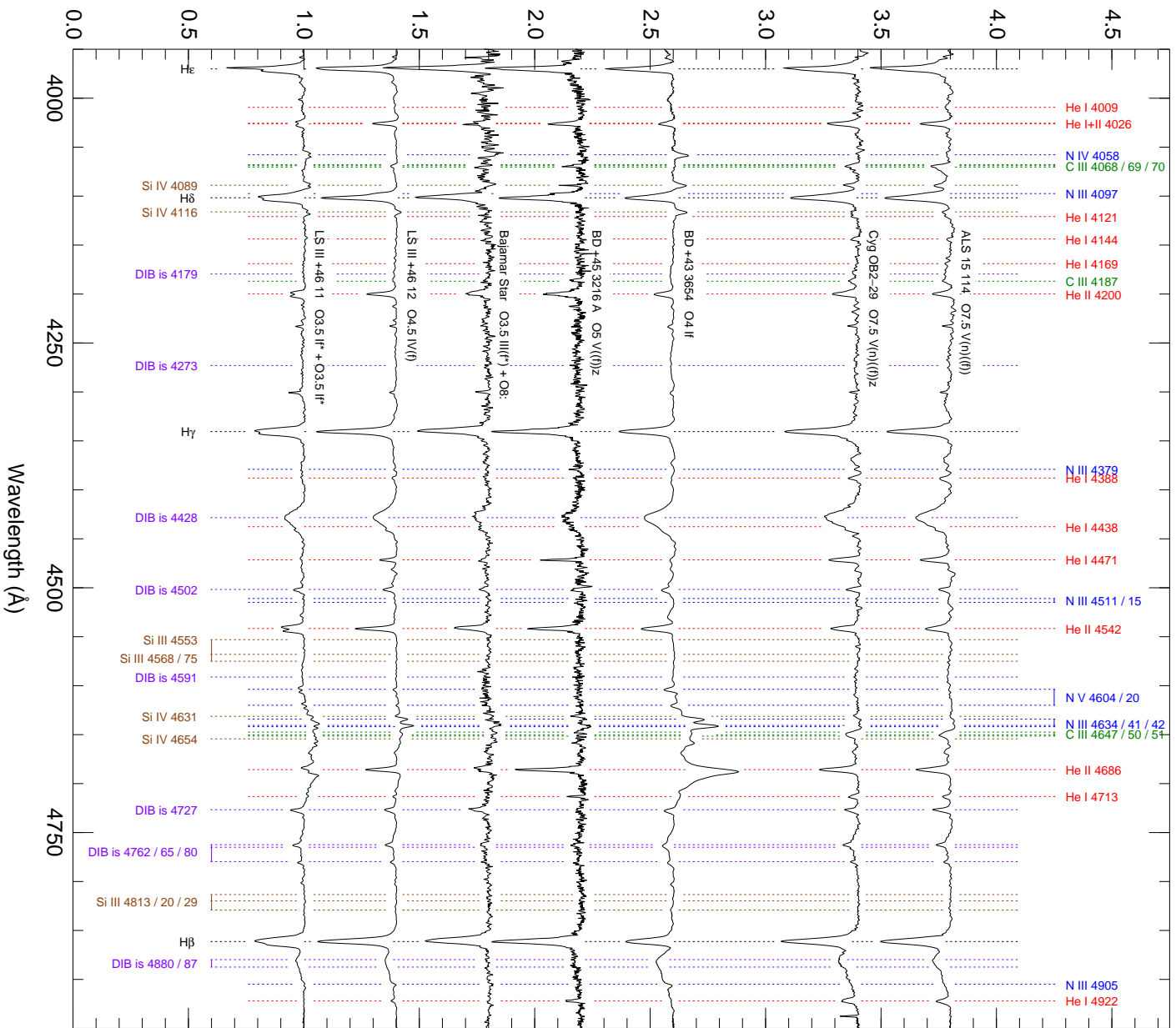


Fig. 2.— (continued).

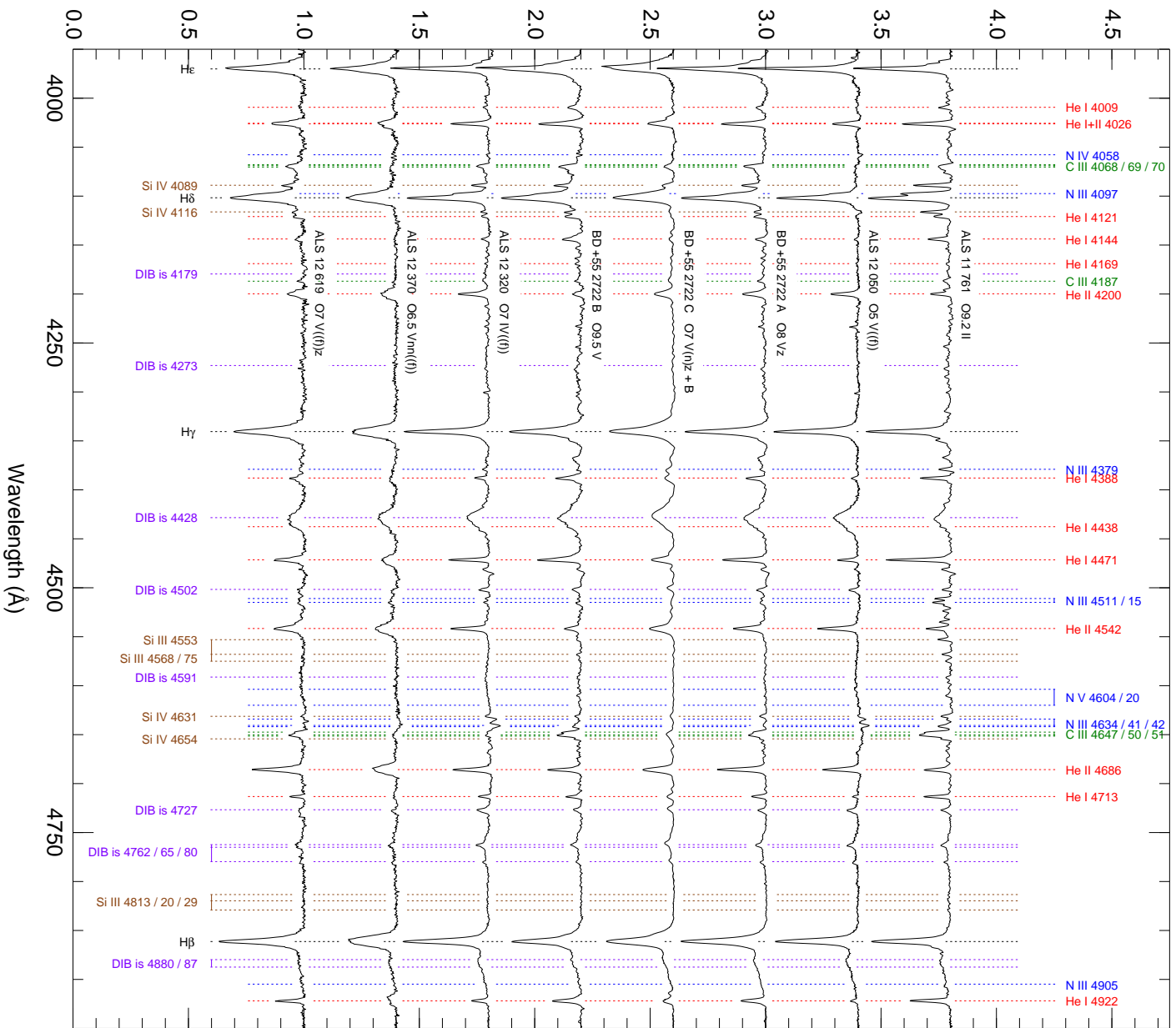


Fig. 2.— (continued).

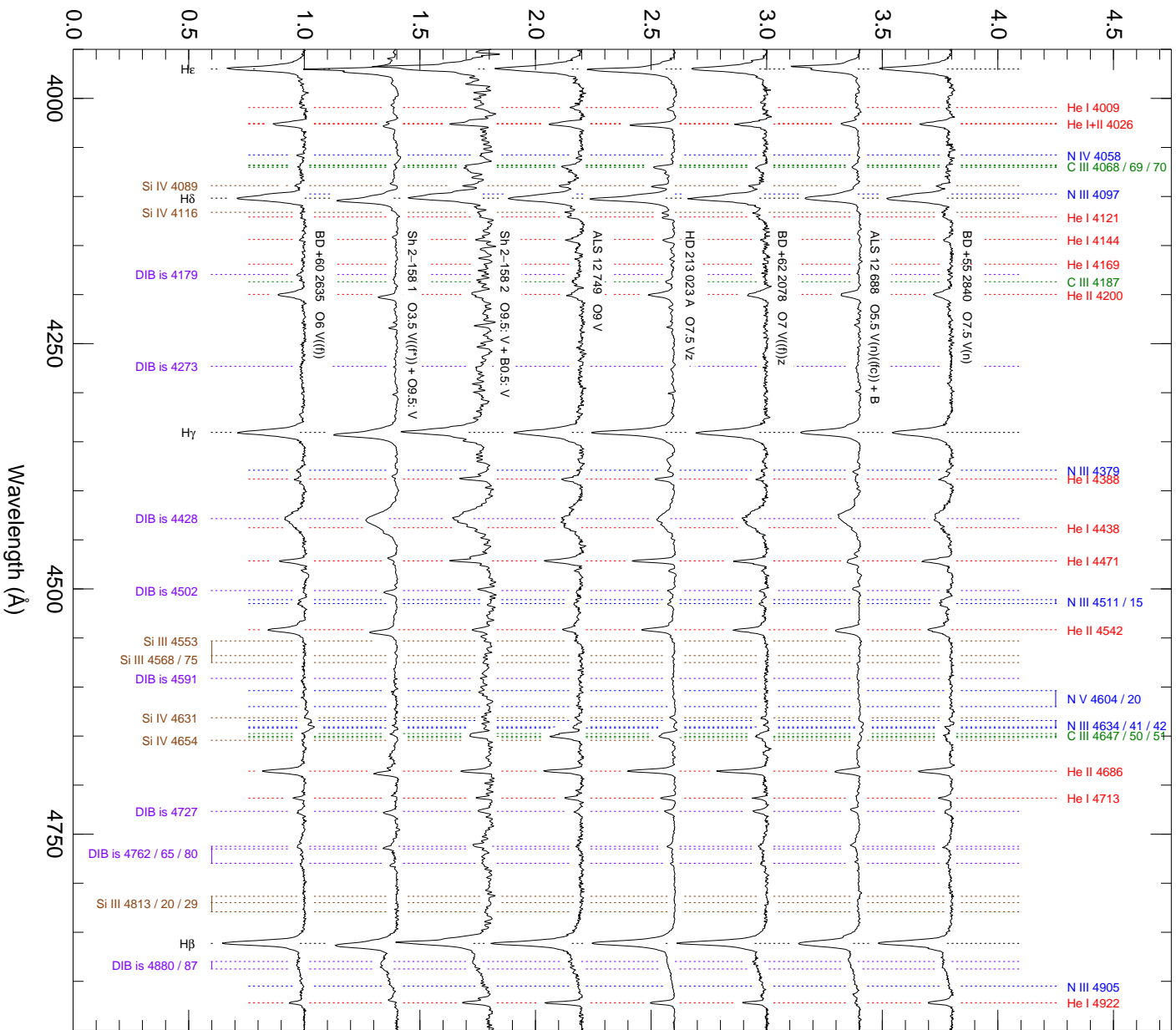


Fig. 2.— (continued).

**BD -16 4826 = ALS 4944.** Hiltner & Johnson (1956) classified this NGC 6618 star as O5 and Garmany & Vacca (1991) as O3 V. Our GOSSS data yield O5.5 V((f))z. Some lines are asymmetric, indicating the possibility of the system being an SB2. Williams et al. (2013) classify this system as an SB1 and give a period of 15.8 d but note that their observations span less than a full orbit.

**ALS 4923.** Vijapurkar & Drilling (1993) classified this star as a rapid-rotator giant, O9.5 III<sub>nn</sub>. GOSSS data reveal that it is really an SB2 composed of two nearly identical main-sequence stars, with spectral types of O8.5 V + O8.5 V. The system was caught with a  $\Delta v$  of  $\sim 400$  km/s, so it is likely to have a short period.

**ALS 4626.** Drilling & Perry (1981) classified this star as O5 V. We obtain a classification of ON6 V((f)).

**BD -14 5014 = ALS 4981.** Crampton et al. (1978) classified this star as O8: V: and Vijapurkar & Drilling (1993) as O9.5 V. We obtain O7.5 V(n)((f)). The star has a visual companion listed in the WDS (2MASS J18222221-1437151) with a last known separation in 2007 of  $7''.2$ . We obtained a separate spectrum of the companion and we found that it is a K star, so the proximity is likely to be the product of a chance alignment, which agrees with the difference in proper motions between the two objects.

**V479 Sct = ALS 5039.** This  $\gamma$ -ray binary (Aharonian et al. 2005) was classified as O7 V((f)) by Motch et al. (1997) and as O6.5 V((f)) by Clark et al. (2001). We derive a slightly earlier classification of ON6 V((f))z from GOSSS data.

**BD -14 5040 = ALS 5025 = LS IV -14 57.** We classify this star as O5.5 V(n)((f)) which, to our knowledge, is the first spectroscopic identification of this target as an O star. Note that the characterization of the object by Kilkeny (1993) was based purely on photometry.

**HD 168137 AaAb = ALS 4915 AaAb = NGC 6611-401 AaAb.** This NGC 6611 system was classified as O8 V by Hiltner & Morgan

(1969). Sana et al. (2009) found it to be a long-period SB2 with spectral types O7 V + O8 V and Sana et al. (2014) was able to marginally resolve the two components. The SB2 character is not visible in the GOSSS data and we derive a classification of O8 Vz.

**ALS 15 360 = NGC 6611-222.** This NGC 6611 star was classified as O7 III((f)) by Hillenbrand et al. (1993). Using GOSSS data we obtain O7 V((f))z.

**HD 168 504 = ALS 4935.** This star was classified as O8 by Morgan et al. (1955) and as O8 III((f)) by Conti (1973). We derive a classification of O7.5 V(n)z from GOSSS data.

**ALS 4880.** Vijapurkar & Drilling (1993) classify this star as O5 V. We obtain a classification of O6 V((f)) with GOSSS data and we select it as a new standard star for this type.

**HD 168 461 = ALS 4931.** Hiltner & Johnson (1956) give a classification of O8 for this object. Our result using GOSSS data is O7.5 V((f)) Nstr.

**BD -10 4682 = ALS 9584.** Hiltner & Johnson (1956) classify this star as O7 and Garmany & Vacca (1991) as O7 V. We classify it as O7 Vn((f)) with GOSSS data.

**BD -04 4503 = ALS 9772.** Hiltner & Johnson (1956) classify this star as O7. We obtain O7 V using GOSSS data.

**HD 175 514 = V1182 Aql = BD +09 3928 = ALS 10 048.** Hiltner & Johnson (1956) originally classified this star as O8 V<sub>nn</sub>. The star was later discovered to be an eclipsing SB2 and Bell et al. (1987) obtained a spectral classification of O9 V<sub>nn</sub> + B3 V. We also see it as an SB2 with GOSSS but the new spectral classification, O7 V(n)((f))z + B implies a significantly earlier primary. The system was caught with a  $\Delta v$  of  $\sim 425$  km/s.

**ALS 18 929 = LSE 107.** This star appears as Osp... in Simbad but there are no references



listed for that classification. Indeed, the only references for this star that appear in the ADS are Reed (2003, 2005) but there is no spectral type there either. One possibility is that the Simbad classification is a photometric one, not a real spectral classification<sup>3</sup>. Another possibility is that the Simbad classification comes from the OB- classification in Drilling & Bergeron (1995). Since this object is an O9.7 in the GOSSS data, this is the first time it receives an O-type spectral classification. The star has sharp lines, indicating a low  $v \sin i$  but we are unable to give a luminosity class because it is a good example of the problem discussed in Appendix A.2 of Walborn et al. (2014). For late-O stars there are two luminosity criteria, the ratios of He II  $\lambda 4686$  to He II  $\lambda 4713$  and of Si IV  $\lambda 4089$  to He I  $\lambda 4026$ , respectively (Table 6 in paper I). For the majority of O9.5-O9.7 stars the two criteria agree but in some cases they yield different answers, with the second criterion providing results that are more consistent with the distance to 30 Doradus for the O9.5-O9.7 stars analyzed there. In the case of ALS 18929, the first criterion yields a luminosity class of II while the second one yields a luminosity class of V. Given the discrepancy, we do not assign a luminosity class to this object. When observing ALS 18929, we placed a nearby star, Tyc 1036-00534-1, on the slit and it turned out to have an F spectral type.

**HDE 344 777 = ALS 10 425.** Turner (1979) classified this star as O9.5 III:. We agree that it is an O star but the GOSSS spectral classification is rather different, O7.5 Vz.

**HDE 344 758 = BD +24 3843 = ALS 10 421.** Hiltner & Johnson (1956) classified this star as O8 V. The GOSSS spectral classification is O8.5 V(n)((f)).

**HDE 338 931 = BD +24 3881 = ALS 10 512.** Hiltner & Johnson (1956) classified this star as O6f. The GOSSS spectral classification is O6 III(f) and we select it as the new standard star for this type.

<sup>3</sup>We discuss below other cases where the lack of references for Simbad classifications do not allow for their verification.

**HDE 338 916 = BD +25 3952 = ALS 10 493.** Hiltner & Johnson (1956) classified this star as O8. The GOSSS spectral classification is O7.5 Vz.

**HDE 227 465 = BD +33 3717 = ALS 10 789.** Hiltner & Johnson (1956) classified this star as O7:. The GOSSS spectral classification is O7 V((f))z.

**HDE 227 018 = BD +34 3828 = ALS 10 695.** Hiltner & Johnson (1956) classified this star as O7. The GOSSS spectral classification is O6.5 V((f))z.

**HDE 227 245 = BD +35 3924 = ALS 10 744.** Hiltner & Johnson (1956) classified this star as O7. The GOSSS spectral classification is O7 V((f))z.

**HDE 228 779 = BD +34 3961 = ALS 11 098.** Hiltner & Johnson (1956) classified this star as O9.5 Ib. The GOSSS spectral classification is O9 Iab.

**HDE 228 854 = V382 Cyg = BD +35 4062 = ALS 11 132.** Pearce (1952) assigned spectral types of O6.5 and O7.5 to the two components of this overcontact eclipsing binary with a period of just 1.8855 d. The GOSSS spectral classification is O6 IVn var + O5 Vn var, with the O6 listed first because it is the brighter component. The system was caught at a  $\Delta v$  of  $\sim 575$  km/s. The var suffix is used because we have another GOSSS observation near conjunction with a spectral type that is incompatible with the two observed near quadrature: the combined spectral subtype is O7 and there is a clear N III  $\lambda 4634$ -41-42 emission (that is absent in the near quadrature spectrum).

**ALS 18 707 = S104 Anon 3.** Crampton et al. (1978) classified this star as O6 V. The GOSSS spectral classification is O6.5 V((f))z. There is a companion  $\sim 3$  magnitudes fainter towards the SW at a distance of  $2''.1$  that we were able to spatially resolve in our long-slit spectra: it is an early B star. The two objects appear to be the brightest stars in an obscured clusetr.

**HD 193 682 = ALS 11 181.** Hiltner & Johnson (1956) classified this star as O5. Using GOSSS data we obtain O4.5 IV(f). It is one of the new

O4-O5.5 IV stars and we use it as one of the new standards.

**HD 193 595 = ALS 11 162.** Roman (1951) classified this star as O8 and Morgan et al. (1953) as O7. The GOSSS spectral classification is O7 V((f)).

**BD +36 4145 = ALS 11 453.** Hiltner & Johnson (1956) classified this star as O9 V and Negueruela et al. (2004) as O8.5 V. The GOSSS spectral classification is O8.5 V(n).

**HDE 229 202 = BD +39 4162 = ALS 11 274.** Hiltner & Johnson (1956) classified this star as O8: V. The GOSSS spectral classification is O7.5 V(n)((f)).

**ALS 11 355 = LS II +39 53.** Vijapurkar & Drilling (1993) classified this star as O7 V:. The GOSSS spectral classification is O8 V(n)((f)). When observing this target, we placed a nearby star, 2MASS J20272914+3945054, on the slit and it turned out to have a G spectral type.

**HD 194 649 AB = ALS 11 324.** Hiltner & Johnson (1956) classified this star as O6.5. The GOSSS spectral classification is O6.5 V((f)). The WDS lists a companion 0'.4 to the SW with a  $\Delta m$  of 0.6 that we are unable to separate in the GOSSS spectra but that is easily seen in unpublished AstraLux lucky images (Maíz Apellániz 2010).

**HDE 228 759 = BD +41 3689 = ALS 11 083 = LS III +41 15.** Mayer & Macák (1971) classified this star as O6. The GOSSS spectral classification is O6.5 V(n)((f))z. LS III +41 14 is located 30'' away and was observed simultaneously.

**LS III +41 14 = ALS 11 081.** Mayer & Macák (1971) classified this star as O9 V. The GOSSS spectral classification is O9.5 V(n). HDE 228 759 is located 30'' away and was observed simultaneously.

**BD +40 4179 = ALS 11 363.** Hiltner & Johnson (1956) classified this star as O8: V. The GOSSS spectral classification is O8 Vz.

**Cyg OB2-B17 = V1827 Cyg = [CPR2002] B17.**

Stroud et al. (2010) discovered that this is an SB2 system composed of two O supergiants with spectral types O7 Iaf and O9 Iaf and a period of 4.0217 d. We obtained one GOSSS epoch in which the two components are clearly separated, as the system was caught with a  $\Delta v$  of  $\sim 450$  km/s, and we obtained a spectral type of O6 Iaf + O9: Iaf. The spectral type of the primary is earlier than the Stroud et al. (2010) result, possibly because of our better spectral resolution. The uncertainty in the secondary spectral type arises from inconsistencies among some He II lines, possibly caused by the strong winds evidenced by the observed emission lines. Indeed, He II  $\lambda 4686$  and N III  $\lambda 4634-41-42$  for the primary appear as strong in emission for the primary as for some O Iafpe stars but we cannot give it that designation because He I  $\lambda 4471$  does not show a P-Cygni profile. In any case, this system clearly deserves follow-up with a high-resolution spectrograph on a 10 m-class telescope.

**Cyg OB2-A24 = 2MASS J20344410+4051584**

**= [CPR2002] A24.** Negueruela et al. (2008) classified this star as O6.5 III((f)). The GOSSS spectral classification is O6.5 III(f), see Table 2 in paper II. The star Cyg OB2-A27 is located 13'.8 away and was placed on the slit. We obtain a spectral classification of B0 Ia, consistent with the Hanson (2003) result.

**2MASS J20315961+4114504.** Comerón & Pasquali (2012) classified this star as O7 V. The GOSSS spectral classification is O7.5 Vz. WR 144 is located 48'.7 away from this star and was placed on the slit.

**Cyg OB2-A11 = ALS 21 079 = [MT91] 267**

**= [CPR2002] A11.** Negueruela et al. (2008) classified this target as O7 Ib-II(f) and Kobulnicky et al. (2012) identified it as an SB1 system with a 15.511 d period. The GOSSS spectral classification is very similar, O7 Ib(f). Cyg OB2-A11 is 1'.8 away from Cyg OB2-12, a well known, highly extinguished B hyper/supergiant (Morgan et al. 1954; Walborn et al. 2015) which we placed on the slit and for which we found a spectral type of B5 Ia. Note, however, that this star is a photometric variable (Salas et al. 2015) and that for late B

stars the He I  $\lambda 4471$ /Mg II  $\lambda 4481$  ratio is luminosity dependent, which leads to differing spectral subtypes in the literature (Clark et al. 2012).

**ALS 15 108 AB = [MT91] 516 AB.** Massey & Thompson (1991) classified this star as O5.5 V((f)). The GOSSS spectral classification is O6 IV((f)) and was obtained with GTC data. Mason et al. (2009) found a B component with  $\Delta m$  of 0.4 magnitudes  $0''.7$  away (see also Caballero-Nieves et al. 2014). We were unable to spatially resolve the secondary with GOSSS but it is clearly seen in unpublished AstraLux lucky images (Maíz Apellániz 2010).

**Cyg OB2-5 B = V279 Cyg B = BD +40 4220 B = Schulte 5 B = ALS 11 408 B.** Cyg OB2-5 B is 3 magnitudes dimmer than Cyg OB2-5 A and is located  $0''.934$  away (Maíz Apellániz 2010). In paper I we mentioned that it is a mid-O star but we were unable to give a precise classification due to the low S/N of the spectrum (the low S/N was caused by the contamination from A). We observed the AB pair again with GOSSS and this time we were able to clearly separate the two stars, with the B component being an O6.5 Iabfp. The p suffix is used due to the anomalous He II  $\lambda 4686$  profile.

**ALS 15 134 = [MT91] 534.** 558] Massey & Thompson (1991) classified this star as O7.5 V. The GOSSS spectral classification is O8 Vz. We also placed on the slit [MT91] 558, located  $1''.0$  away, and found it is an F star.

**Cyg OB2-22 D = Schulte 51 = [MT91] 425 = ALS 15 149.** Cyg OB2-22 D is part of the Cyg OB2-22 Trapezium-like system (Maíz Apellániz 2010), in which we classified three O stars in paper I: A, Ba, and C (= V2185 Cyg). Massey & Thompson (1991) classified the D component as B0 V and several subsequent works repeat this classification. In the GOSSS data, we classify it as O9.5 Vn, which is the first time it has been recognized as an O star.

**ALS 15 144 = [MT91] 378.** Massey & Thompson (1991) classified this star as B0 V and according to Kobulnicky et al. (2014) it is an SB1. However, according to GOSSS data it is an O9.7 III(n) and,

to our knowledge, it has never been classified as an O star before.

**ALS 15 119 = [MT91] 588.** Massey & Thompson (1991) classified this star as B0 V. However, according to GOSSS data it is an O9.5 IV(n) and, to our knowledge, it has never been classified as an O star before. We also placed the nearby Cyg OB2-18 on the slit: it is an early-B supergiant, in agreement with previous classifications (e.g. Kiminki et al. 2007).

**Cyg OB2-17 = ALS 15 105 = Schulte 17 = [MT91] 339.** Massey & Thompson (1991) classified this star as O8.5 V and according to Kobulnicky et al. (2014) it is an SB1. The GOSSS spectral classification is O8 V. This star was observed placing ALS 15 111 on the same slit.

**Cyg OB2-16 = LS III +41 33 = ALS 11 415 = Schulte 16 = [MT91] 299. = Cyg OB2-A43 = [CPR2002] A43** Hiltner & Johnson (1956) classified this star as O8 V. The GOSSS spectral classification is O7.5 IV(n). This star was observed placing Cyg OB2-6 on the same slit.

**Cyg OB2-6 = LS III +41 35 = ALS 11 418 = Schulte 6 = [MT91] 317 = BD +40 4221.** Johnson & Morgan (1954) classified this star as O8 (V). The GOSSS spectral classification is O8.5 V(n). This star was observed placing Cyg OB2-16 on the same slit.

**ALS 15 115 = [MT91] 485.** Massey & Thompson (1991) classified this star as O8 V and we obtain the same spectral classification with GOSSS. Kobulnicky et al. (2014) find it is an eccentric SB1 with a period of 4066 d.

**ALS 15 111 = [MT91] 376.** Massey & Thompson (1991) classified this star as O8 V and we obtain the same spectral classification with GOSSS. This star was observed placing Cyg OB2-17 on the same slit.

**Cyg OB2-27 AB = ALS 15 118 AB = Schulte 27 AB = [MT91] 696 AB.** Kiminki et al. (2015) classified this eclipsing SB2 as O9.5 V + B0.5 V

and measured a distance of  $1.32 \pm 0.07$  kpc. With GOSSS we caught this system with a  $\Delta v$  of  $\sim 450$  km/s and obtain a classification of O9.7 V(n) + O9.7 V:(n). Salas et al. (2015) measured the period of this eclipsing binary as 1.46917 d and Laur et al. (2015) detected a small period change. Caballero-Nieves et al. (2014) found a B companion with a  $\Delta m = 0.94$  and a separation of  $0''.023$ . We also placed the nearby [MT91] 674 on the slit and we found it is a K star.

**Cyg OB2-73 = Schulte 73.** Kiminki et al. (2009) classified this star as O8 III + O8 III and measured a period of 17.28 d, which were later revised to O8.5 III: + O9 III: and 34.88 d by Kobulnicky et al. (2014). With GOSSS we caught the system at a  $\Delta v$  of  $\sim 175$  km/s and we obtain a classification of O8 Vz + O8 Vz, clearly excluding the prior giant classifications because the  $z$  ratio is larger than 1.1 for both components.

**Cyg OB2-25 A = ALS 15 104 A = Schulte 25 A = [MT91] 531 A.** Massey & Thompson (1991) classified this system as O8.5 V. The GOSSS spectral classification is O8 Vz and we are able to spatially separate the B component, which turns out to be an early-B star. Caballero-Nieves et al. (2014) measure a separation between A and B of  $1''.45$  and a visual  $\Delta m$  of 0.5 magnitudes, which is consistent with the GOSSS data and with what we see in unpublished AstraLux lucky images (Maíz Apellániz 2010).

**Cyg OB2-10 = BD +41 3804 = Schulte 10 = [MT91] 632 = ALS 11 434.** Hiltner & Johnson (1956) classified this system as O9.5 Ia. The GOSSS spectral classification is O9.7 Iab. Caballero-Nieves et al. (2014) detected a B component with a separation of  $0''.22$  and a  $\Delta m$  of 2.0 which we were unable to spatially separate in the GOSSS data but that can be seen in unpublished AstraLux lucky images (Maíz Apellániz 2010).

**ALS 15 125 = [MT91] 736.** Massey & Thompson (1991) classified this star as O9 V. The GOSSS spectral classification is O9.5 IV:, with the uncertainty in the spectral type arising from the discrepant results for the He II  $\lambda 4686$  to He II  $\lambda 4713$

and the Si IV  $\lambda 4089$  to He I  $\lambda 4026$  ratios. This star was observed placing Cyg OB2-29 on the same slit.

**ALS 15 114 = [MT91] 771.** 775] This system is an SB2 with O7 V + O9 V spectral types and a period of 2.82105 d according to Kobulnicky et al. (2014). We only obtained one GOSSS epoch and it was at an unfavorable phase, so we can only derive a combined spectral type of O7.5 V(n)((f)). We placed the neighbor [MT91] 775 and determined it is a K star.

**Cyg OB2-29 = ALS 15 110 = Schulte 29 = [MT91] 745.** Massey & Thompson (1991) classified this star as O7 V and Kobulnicky et al. (2014) determined it is an SB1 with a 151.2 d period. The GOSSS spectral classification is O7.5 V(n)((f))z. This star was observed placing ALS 15 125 on the same slit.

**BD +43 3654 = ALS 11 429.** Comerón & Pasquali (2007) classified this object as O4 If and proposed it is a runaway ejected from Cyg OB2. The GOSSS data yield the same spectral classification.

**BD +45 3216 A = ALS 11 435 A.** Hiltner & Johnson (1956) classified this target as O8. GOSSS data yields a rather different spectral classification of O5 V and there is a good explanation for the difference. The WDS lists a B companion with a  $\Delta m$  of 0.3 mag and a separation of  $0''.8$  which is clearly seen in our unpublished AstraLux lucky images (Maíz Apellániz 2010). We were able to obtain GOSSS spectra under good seeing conditions and spatially separate both components. The O5 V((f))z classification corresponds to the A component while the B component is an early B star, which explains the previous O8 classification (a reasonable classification for the combined spectrum).

**Bajamar Star = 2MASS J20555125+4352246.** Comerón & Pasquali (2005) identified this star as the main ionizing source of the North America Nebula<sup>4</sup> and classified it as O5 V. We observed

<sup>4</sup>We adopt the name “Bajamar Star” for the object due to its position relative to the North America Nebula, just to the east of the “Florida Peninsula”. “Islas de Bajamar”, mean-

this system several times and we noticed that the velocity of the He I lines was not the same as that of the He II and that there were significant variations in the relative velocity ( $\Delta v \sim 300$  km/s) between epochs. Therefore, the system is an SB2 composed of a star earlier than the average type obtained by Comerón & Pasquali (2005) and a later star. Our best current spectrum is one where we caught the system with the GTC with a  $\Delta v$  of  $\sim 100$  km/s and from which we assign spectral types of O3.5 III((f\*)) + O8:. Note that prior to 2015 there were only two known Galactic O stars in the northern hemisphere earlier than O4, Cyg OB2-7 and Cyg OB2-22 A, see paper I. Maíz Apellániz et al. (2015b) added two more (see below) and in this paper we identify the fifth and the sixth cases (the primary here and the primary of Sh 2-158 1).

**LS III +46 12 = ALS 11 449.** Mayer & Macák (1973) classified this star as O6. In Maíz Apellániz et al. (2015b,a) we used GOSSS and other data to study it and classify it as O4.5 V((f)). Here, we change the luminosity classification to IV with the introduction of that class for the spectral subtypes O4-O5.5. The change from IV to V partially (but not completely) alleviates the luminosity/distance discrepancy within Berkeley 90 discussed in Maíz Apellániz et al. (2015b,a). Therefore, we cannot yet discard that there is a hidden binary component in LS III +46 12.

**LS III +46 11 = ALS 11 448.** Motch et al. (1997) classified this star as O3-5 III(f)e. In Maíz Apellániz et al. (2015b,a) we used GOSSS and other data to discover it is an eccentric massive SB2 binary with two similar components, each with spectral type O3.5 If\*. As previously mentioned, the spectral classification of this 97.3 d binary raised the number of northern-hemisphere Galactic O stars earlier than O4 to four objects.

**ALS 11 761 = LS III +46 50.** Negueruela & Marco (2003) classified this star as O9.5 III. The GOSSS spectral classification is O9.2 II and we use it as one of the new standards.

**ALS 12 050 = LS III +57 18.** Russeil et al. (2007) classified this star as O5 V. The GOSSS spectral classification is O5 V((f)). We also placed the nearby star Tyc 3976-00299-1 on the slit and we found it is an A star.

**BD +55 2722 A = ALS 12 292 A = LS III +55 36 A.** BD +55 2722 is a Trapezium-like system at the core of the open cluster Teutsch 127. The A component is the brightest one and was classified by Mayer & Macák (1973) as O9 V, though it is likely their result included also the nearby B component, which we spatially resolve (see below). The GOSSS spectral classification is O8 Vz.

**BD +55 2722 C = LS III +55 37 = ALS 12 293.** BD +55 2722 C is the wide component in the BD +55 2722 ABC and is located  $10''$  away from the center of the AB pair. Crampton et al. (1978) classified it as O7 V. The GOSSS spectral classification is O7 V(n)z + B, which is the first time that this system has been identified as an SB2 to our knowledge. The system was caught at a  $\Delta v$  of  $\sim 500$  km/s.

**BD +55 2722 B = ALS 12 292 B = LS III +55 36 B.**

BD +55 2722 B is the closer companion to BD +55 2722 A and is located  $1''.7$  away with a  $\Delta m$  of 0.3 mag according to the WDS and confirmed in our unpublished AstraLux lucky images (Maíz Apellániz 2010). Its existence is referred to in several of the papers on BD +55 2722 but, to our knowledge, no spectral type has ever been published (see e.g. Saurin et al. 2010). We placed the slit along the AB position angle and we were able to spatially separate the two components. The GOSSS spectral type for BD +55 2722 B is O9.5 V, making it the third O star in the Trapezium system.

**ALS 12 320 = LS III +55 45.** McCuskey (1955) classified this object as O8. The GOSSS spectral classification is O7 IV((f)) and we use it as one of the new standards. The nearby star 2MASS J22202471+5608080 was also placed on the slit: it is a late-B star.

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ing “low-tide islands” in Spanish, was the original name of the Bahamas islands because many of them are only easily seen from a ship during low tide.

**ALS 12 370 = LS III +55 65.** Hiltner (1956) classified this object as O5. The GOSSS spectral classification is O6.5 Vnn((f)).

**ALS 12 619 = LS III +57 90.** Massey et al. (1995) classified this star as O8 V((f)). The GOSSS spectral classification is O7 V((f))z.

**BD +55 2840 = ALS 12 685.** Hiltner & Johnson (1956) classified this star as O7.5p. The GOSSS spectral classification is O7.5 V(n).

**ALS 12 688 = LS III +56 109.** This star appears as O... in Simbad but we have not found any reference to any spectral classification, so we suspect the reason for the listing is a photometric classification. We have found it to be not only an O star but an SB2 as well. The GOSSS spectral type is O5.5 V(n)((fc)) + B, with the companion having He I  $\lambda 4471$  in absorption but no sign of He II  $\lambda 4542$  (hence, we can only classify it as a B) and this system being caught on two different epochs with a  $\Delta v$  of 500 km/s. Lewandowski et al. (2009) confirm the binary nature of the system by identifying it as an eclipsing binary with a 2.02170 d period.

**BD +62 2078 = ALS 12 408.** Hiltner & Johnson (1956) classified this star as O7. The GOSSS spectral classification is O7 V((f))z.

**HD 213 023 A = BD +62 2081 = ALS 12 424.** Morgan et al. (1955) classified this star as O9 V:. The GOSSS spectral classification is O7.5 Vz, which is significantly different. We suspect that the reason is that the original spectral type included the B component, located at a separation of 1''7 with a  $\Delta m$  of 0.4 according to the WDS. The GOSSS spectra spatially separated the two components and we obtained an early B spectral type for the companion.

**ALS 12 749 = LS III +56 119.** Massey et al. (1995) classified this star as O9.5 V((f)). The GOSSS spectral classification is O9 V.

**Sh 2-158 2 = 2MASS J23133024+6130103.** Deharveng et al. (1979) correctly identified that

this object and Sh 2-158 1 (see below) are the two ionizing stars of the H II region Sh 2-158 2 (or NGC 7538) while the bright nearby 2MASS J23133680+6130395 is a K star (which we confirmed by placing one of our slits on it). However, they only provided rough spectral types of O7 for both sources. We have observed Sh 2-158 2 with GOSSS and found that it is an SB2 caught with a  $\Delta v$  of  $\sim 275$  km/s and spectral types O9.5: V + B0.5: V. Those are significantly later than O7, so we suspect that the previous classification was intended for Sh 2-158 1 (though that is also inaccurate, see below).

**Sh 2-158 1 = Tyc 4279-01463-1.** As for the previous object, there is little information about Sh 2-158 1 in the literature. That is why we were surprised to find out with GOSSS that it is a very early type SB2 caught with the GTC with a  $\Delta v$  of  $\sim 375$  km/s and spectral types of O3.5 V((f\*)) + O9.5: V. As previously mentioned, the primary of this system is the fifth Galactic O star earlier than O4 in the northern hemisphere (the sixth is the primary of the Bajamar Star, see above). Most of the He I  $\lambda 4471$  absorption originates in the secondary while most of the He II  $\lambda 4542$  absorption originates in the primary. If the absorption is considered to originate in a single object, the combined spectral type would be O4.5 (which is still too early to explain the previous classification as O7).

**BD +60 2635 = ALS 13 256.** Martin (1972) classified this star as O9 III. The GOSSS spectral classification is O6 V((f)). The original classification was done with objective-prism data, so a possible explanation for the discrepancy is the low quality of the original data. However, Negueruela & Marco (2003) classified this star as ON7 III(f), which is also discrepant (we see a N enhancement in the GOSSS data but not significant enough to classify it as ON) so it is also possible that the star is variable.

**BD +66 1661 = ALS 13 323.** Hiltner & Johnson (1956) classified this star as O9 V. The GOSSS spectral classification is O9.2 V.

**V747 Cep = BD +66 1673 = ALS 13 375 = NGC 7822-3.** This object is an eclipsing binary with a period of 5.33146 d in the open cluster Berkeley 59 that was classified as O5 Vn((f)) by Majaess et al. (2008). The GOSSS spectral type is O5.5 V(n)((f)). No double lines were seen in our data. We placed the nearby 2MASS J00015191+6731474 on the slit and found it is an early B star.

**BD +66 1675 = ALS 13 379.** This object is the brightest star in the open cluster Berkeley 59 and was classified as O7 by Hiltner & Johnson (1956). The GOSSS spectral classification is O7.5 Vz.

**BD +66 1674 = ALS 13 378.** This object is the second brightest star in the open cluster Berkeley 59 and was classified as O9.5 V by Bisiacchi et al. (1982). The GOSSS spectral classification is O9.7 IV:. The uncertainty in the luminosity class is caused by the discrepancy between the He II  $\lambda 4686$  to He II  $\lambda 4713$  criterion (which yields III) and the Si IV  $\lambda 4089$  to He I  $\lambda 4026$  criterion (which yields V), another example of the effect previously mentioned.

**Tyc 4026-00424-1 = NGC 7822-29 = ALS 17 957.**

This object is also located in Berkeley 59 and was classified as O9 by Walker (1965). The GOSSS spectral classification is O7 V((f))z. We also placed a nearby star, ALS 13 380, on the slit and found it is an early B star.

**ALS 6351 = LS I +62 139.** Hiltner & Johnson (1956) classified this star as O7. The GOSSS spectral classification is O7 Vz.

**BD +60 134 = ALS 6405.** Popper (1950) classified this star as O7. The GOSSS spectral classification is O5.5 V(n)((f)).

**HD 5689 = BD +62 178 = ALS 6425.** Hiltner & Johnson (1956) classified this star as O6. The GOSSS spectral classification is O7 Vn((f)).

**ALS 6967 = LS I +59 112.** Hiltner & Johnson (1956) classified this object as O9 V. We observed

it star with GOSSS and found it is an SB2 with spectral types O8 V + B0: V caught with a  $\Delta v$  of 200 km/s. To our knowledge this is the first identification of this object as a spectroscopic binary.

**BD +61 411 A = ALS 7203.** Hiltner & Johnson (1956) classified this star as O6. The GOSSS spectral classification is O6.5 V((f))z. There is a B component detected as a separate source in 2MASS located 5''.672 toward the NE. We were able to spatially separate it from A and we found it is an early B star.

**ALS 7833 = LS I +57 138.** This is one of the two bright stars in the open cluster Alicante 1. Negueruela & Marco (2003) classified it as O7 V. The GOSSS spectral classification is O8 Vz.

**MY Cam = BD +56 864 = ALS 7836.** This is the second of the two bright stars in the open cluster Alicante 1. Hiltner & Johnson (1956) classified it as O6nn and Lorenzo et al. (2014) discovered it is an overcontact binary composed of two O stars with a period of 1.1754514 d. In the GOSSS data the two components are separated by a  $\Delta v$  of  $\sim 500$  km/s and we assign them spectral types O5.5 V(n) + O6.5 V(n).

**BD +50 886 = ALS 7868.** This object is the main ionizing source of the H II region Sh 2-206 (= NGC 1491) and was classified by Moffat et al. (1979) as O5neb. The GOSSS spectral classification is O4 V((fc)).

**BD +52 805 = ALS 7928.** This object is the brightest star in the open cluster Waterloo 1 and was classified by Moffat et al. (1979) as O9.5 V. The GOSSS spectral classification is O8 V(n).

**ALS 8272 = LS V +38 12.** This object was classified by Georgelin et al. (1973) as O9 V. We observed it with GOSSS and found it is an SB2 with spectral types O7 V((f)) + B0 III-V caught with a  $\Delta v$  of 325 km/s. To our knowledge this is the first identification of this object as a spectroscopic binary. We placed the neighbor HDE 277 990 on the slit and found it is an F star.

**ALS 8294 = LS V +33 15 = NGC 1893-149.** Walker & Hodge (1968) classified this star as O7. The GOSSS spectral classification is O7 V(n)z.

**ALS 19 265 = Rubin & Losee 128.** This object was classified as O7 V by Chromey (1979), who was searching for O stars at large Galactocentric radii near the Galactic anticenter. We find the spectrum to be quite remarkable and we classify it as O4.5 V((c))z, with the ((c)) suffix indicating C III  $\lambda$ 4650 emission without apparent N III  $\lambda$ 4634-41-42 emission, an effect that we have not seen in any other O star. Another peculiarity is the difference between the He I and He II profiles. We should caution that ALS 19 265 could be an evolved low-mass star. For example, we also observed another one of the stars in Chromey (1979), ALS 19 270, and its GOSSS spectrum looks quite similar to that of ALS 19 265 though it is now known to be a planetary nebula nucleus or PNN (Aller et al. 2015). To investigate this further we downloaded the SDSS data for the target. In the images it appears as a blue object but no nebulosity is seen in the  $r$  band, as it would be expected of a PN (the star could still be a naked sdO). We have also processed the SDSS photometry through CHORIZOS (Maíz Apellániz 2004, 2013b; Maíz Apellániz et al. 2014b) assuming that ALS 19 265 is a ZAMS O star. Under those circumstances, it would have to be located at a distance close to 30 kpc and its extinction would have a large value of  $R_{5495}$  (between 5 and 6, an indication that some of the extinction takes place in an environment depleted of small dust grains such as an H II region or a PN). Such a large distance would be extreme for a Galactic O star (with the likely low metallicity providing a possible explanation for the peculiar spectrum) but the available information does not exclude the possibility of the object being a lower luminosity, lower mass, closer evolved star. Gaia should be able to provide us with a distance measurement and decide between the two options.

**HDE 256 725 A = BD +19 1339 A = ALS 46.** This star is the brightest object of the Trapezium system HDE 256 725 and was classified as O6 by Moffat et al. (1979). The GOSSS spectral type is O5 V((fc)).

**HDE 256 725 B = BD +19 1339 B = ALS 47.** This star is the second brightest object of the Trapezium system HDE 256 725 and was classified as O8 III by Moffat et al. (1979). The GOSSS spectral type is O9.5 V.

**Tyc 0737-01170-1 = NGC 2264 +10 60.** Voroshilov et al. (1985) classified this star as O5:. The GOSSS spectral classification is O7 Vz. We also placed the nearby ALS 9044 and we found it is a late-B supergiant.

**ALS 85.** This star was classified as O9.5 IV by Moffat et al. (1979). Aldoretta et al. (2015) find two dim companions. The GOSSS spectral type is O7.5 V. We have applied a CHORIZOS analysis to this star similar to the one above for ALS 19 265. If this target is a ZAMS O star it would be located at a distance of  $\sim 7.5$  kpc. The inclusion of the mentioned two dim companions would place it slightly closer but if the star is slightly evolved it should be slightly farther away. Therefore, this is a good candidate for an O star at large Galactocentric radius, something that could be confirmed once the Gaia distance becomes available.

**ALS 207.** This object is the main ionizing source of the H II region Sh 2-301 (= RCW 6) and was classified as O7 by Moffat et al. (1979). The GOSSS spectral classification is O6.5 V((f)).

**BD -15 1909 = ALS 552.** Fitzgerald & Moffat (1980) classified this star as O8. The GOSSS spectral classification is O6.5 V((f))z.

**ALS 458 = Sh 2-306 4.** Moffat et al. (1979) classified this star as O5. The GOSSS spectral classification is O6.5 V((f))z.

**V441 Pup = 4U 0728-25 = ALS 437.** This X-ray binary was classified as O8/9 Ve by Negueruela et al. (1996). The GOSSS spectral classification is O5: Ve. The reason for the difference in the classifications is that the GOSSS spectral types do not take into consideration the infilling of He I  $\lambda$ 4471 (i.e. they are strict, not corrected, spectral types), which is common among Oe stars. This is the earliest spectral type we



have assigned to an Oe star in GOSSS (the previous record holder was HD 39 680 = V1382 Ori, an O6).

**CPD -26 2704 = ALS 830.** This object in the Haffner 18 open cluster was classified as O7k by Fitzgerald & Moffat (1974). The GOSSS spectral type is O7 V(n). We placed another cluster star, ALS 832, on the slit and found it is an early-B star.

**V467 Vel = CPD -45 2920 = ALS 1135.** This system is an SB2 with O6.5 V + B1 V spectral types and a period of 2.753 d according to Fernández Lajús & Niemelä (2006). We only obtained one GOSSS epoch and it was at an unfavorable phase, so we can only derive a combined spectral type of O6.5 V(n)((f)). Given the large magnitude difference, the secondary does not seem to affect the combined spectral type. We placed the nearby Tyc 8151-01072-1 on the slit and found is an early-B star.

**CPD -49 2322 = ALS 1267.** This object in the Pismis 11 open cluster was classified as O8 V by Marco & Negueruela (2009). The GOSSS spectral type is O7.5 V((f)).

**HD 90 273.** Hoffleit (1956) classified this object as O7. The GOSSS spectral type is ON7 V((f)). We placed the nearby star HDE 302 748 on the slit and found it is a mid-B star.

**THA 35-II-42 = WR 21a.** Niemelä et al. (2006) discovered that this star is a binary, assigned it spectral classifications of WN6h + O, and noted that its spectrum resembles that of HD 93 162 (= WR 25). However, as pointed out in paper II, Crowther & Walborn (2011) moved HD 93 162 into the early Of/WN (or “early-slash”) category on the basis of its P-Cygni H $\beta$  profile. Here we do the same with THA 35-II-42 and assign it a spectral type of O2 If\*/WN5. We do not see He I  $\lambda$ 4471 from the secondary, which is consistent with its recent identification by Tramper et al. (2016) as an O3 star, but it is quite possible that our classification corresponds to a composite spectrum (we only have one epoch with a good S/N).

We placed the nearby star Tyc 8608-00069-1 on the slit and found it is a mid-B star.

**HD 89 625 = CPD -59 2044 = ALS 1492.** Cannon & Mayall (1949) classified this star as B0 (chart 135) and Houk & Swift (1999) as B3/4 V:. The GOSSS spectral type is ON9.2 IVn and is discussed in more detail in Walborn et al. (2016). To our knowledge this object had never been classified as an O star.

**2MASS J10224377-5930182 = [VRV91] 85.** This object is located in the little-studied open cluster [KPS2012] MWSC 1797 (Kharchenko et al. 2013) and was classified as B0: V by van Genderen et al. (1991). We observed it with GOSSS and we found it is an O8 V(n), which is the first time it has been identified as an O star. We placed the nearby star Hen 3-406 on the slit and found is an early-type Be star. Note that van Genderen et al. (1991) incorrectly claimed that Hen 3-406 was an O-type dwarf.

**2MASS J10224096-5930305 = [VRV91] 82.** This object is also located in [KPS2012] MWSC 1797 and it was classified as O V: by van Genderen et al. (1991). The GOSSS spectral type is O7 V((f))z.

**ALS 18 551.** This star in Collinder 228 appears as O5 in Simbad but this is just a photometric classification from Wramdemark (1976), not a spectroscopic classification. The GOSSS spectral type is O4.5 V(n)z + O4.5 V(n)z with the system caught with a  $\Delta v$  of  $\sim 450$  km/s. This is the first time this system is identified as being an SB2 and having an O-type spectral classification.

**2MASS J10584671-6105512.** This target in Collinder 228 has no current entry in Simbad and, to our knowledge, has never been described in any publication. We observed it because we placed it on the same slit as ALS 18 553 (see below) and we discovered it is an O8 Iabf, another example of a new O star.

**ALS 18 553.** This star in Collinder 228 appears as O5+ in Simbad but this just a photometric classification from Wramdemark (1976), not a spectroscopic classification. The GOSSS spectral type

is O6 IIf, which is the first time this system has received an O-type spectral classification.

**2MASS J10583238-6110565.** This target in Collinder 228 has no current entry in Simbad and, to our knowledge, has never been described in any publication. We observed because we placed it on the same slit as ALS 18553 (see above) and we discovered it is an O5 V((f)) + O7 V((f)) caught with a  $\Delta v$  of  $\sim 200$  km/s. This is the first time this system is identified as being an SB2 and having an O-type spectral classification.

**THA 35-II-153.** This target in Collinder 228 has one single entry in Simbad (The 1966) and no spectral classification. We observed it because we placed it on the same slit as a repeat observation for ALS 2063 (see paper II) and we found it to be an O3.5 If\*/WN7. Early Of/WN stars are quite rare (there are only two in paper II and two more, including this one, in this paper) but to find a new example next to an O Iafpe star such as ALS 2063 (another rare class with just six examples in paper II) is simply remarkable. What is less surprising is that this coincidence takes place in the Carina Nebula, the richest stellar nursery within 3 kpc of the Sun.

**HD 97966 = CPD -58 3372 = ALS 2276.** Morgan et al. (1955) classified this star as O7.5. The GOSSS spectral classification is O7 V((f))z and we select it as the new standard star for this type.

**HD 97319 = CPD -60 2606 = ALS 2217.** Feast et al. (1961) classified this star as O9.5 Ib. The GOSSS spectral classification is O7.5 IV((f)) and we use it as one of the new standards. We placed the nearby HD 97352 on the slit and found it is an early-B star.

**EM Car = HD 97484 = CPD -60 2638 = ALS 2232.** Solivella & Niemelä (1986) observed this previously known eclipsing SB2 and derived spectral types of O7.5 + O8.5. The GOSSS spectral types are O7.5 V((f)) + O7.5 V((f)), with the system caught at a  $\Delta v$  of  $\sim 475$  km/s. We placed the nearby object HDE 306190 on the slit and found it is an early-B star.

**NGC 3603 HST-51.** Moffat (1983) classified this star in NGC 3603 as O4 V(f) and Melena et al. (2008) suggested an earlier type with a later companion. The GOSSS spectral type is O5.5 V(n) but the line profiles are anomalous, indicating that it may indeed be a composite spectrum.

**NGC 3603 HST-48.** Melena et al. (2008) classified this star in NGC 3603 as O3.5 If. The GOSSS spectral type is the same with the addition of the prescriptive \* suffix, i.e. O3.5 If\*. We use this object as one of the new standards.

**NGC 3603 HST-24.** Melena et al. (2008) classified this star in NGC 3603 as O4 V. The GOSSS spectral type is O4 IV(f) and this is one of the new O4-O5.5 stars with luminosity class IV.

**NGC 3603 MTT 25.** Melena et al. (2008) classified this star in NGC 3603 as O3 V((f)). The GOSSS spectral type is O5 V(n), with He I  $\lambda 4471$  clearly detected.

**HD 99546 = CPD -58 3620 = ALS 2342.** Morgan et al. (1955) classified this star as O8. The GOSSS spectral type is O7.5 V((f)) Nstr.

**HD 110360 = CPD -59 4396 = ALS 2732.** Morgan et al. (1955) classified this star as O7 and Mathys (1989) identified it as an ON star. Walborn et al. (2011) used GOSSS data to classify it as ON7 Vz. Here, with the new definition of the OVz phenomenon by Arias et al. (2016) we reclassify it as ON7 V.

**CPD -61 3973 = ALS 3153.** Vijapurkar & Drilling (1993) classified this star as O7 III. The GOSSS spectral type is O7.5 V((f)). We placed the slit on the nearby Tyc 9008-01250-1 and found it is an F star.

**HD 122313 = CPD -61 4286 = ALS 3187.** Houk et al. (1976) classified this star as O5/7. The GOSSS spectral type is O8.5 V.

**ALS 17591 = [OM80] 35.** This object is listed as OB+ in Orsatti & Muzzio (1980) but, to our knowledge, it has never been classified as an O star. With GOSSS we identify it as such and assign it a spectral classification of O5: n(f)p, noting that He II  $\lambda$ 4686 has a centrally reversed (and possibly variable) emission with the red peak stronger than the blue one. We placed the slit on the nearby Tyc 8706-00582-1 and found out it is a late-B star.

**ALS 3386.** Bassino et al. (1982) classified this star as O6 If. The GOSSS spectral type is O6 Iaf. We placed the slit on the nearby Tyc 8696-00095-1 and found it is an F star.

**ALS 18049.** Georgelin et al. (1994) derived a photometric classification of O7 V for this star but, to our knowledge, there are no published spectral classifications. The GOSSS spectral type is O9 V, making this another case of a first-time O-type spectral classification. Note that ALS 18049 appears to be the ionizing source of a well defined H II region seen in both H $\alpha$  and WISE MIR images. We placed the slit on the nearby 2MASS J15441197-5356471 and found it is an F star.

**Muzzio III-9.** Muzzio (1974) derived a photometric classification of O5+: for this star but, to our knowledge, there are no published spectral classifications. The GOSSS spectral type is O8 Ib, making this another case of a first-time O-type spectral classification. We placed the slit on the nearby Muzzio III-10 and found it is a B star but the star is weak so the S/N of the spectrum is poor.

**HD 145 217 = CPD -49 8996 = ALS 3499.** Feast et al. (1961) classified this star as O8. The GOSSS spectral type is O8 V. However, some weak Si III and O II lines are visible, making it likely that this is a composite spectrum of a slightly earlier O star and an early-B star.

**HD 144 647.** Feast et al. (1961) classified this star as O8. The GOSSS spectral type is O8.5 V(n).

**HDE 328 209 AB = CPD -44 7916 = ALS 3624.** Feast et al. (1961) classified this star as O9.5 I(a). The GOSSS spectral type is ON9 Ib-Iap and is discussed in Walborn et al. (2016). OWN data (Barbá et al. 2010) reveal it to be a short-period SB2. Unpublished AstraLux Sur images reveal a visual companion (B) about 3'' to the East that is unresolved in the GOSSS data.

**HDE 329 100 A = ALS 3815.** There is some confusion surrounding this double system, starting with the current classification of G0 in Simbad, which is clearly wrong. According to the WDS there are two components separated by 4''0 with a position angle of 105 degrees and a  $\Delta m$  of 2 magnitudes. We have unpublished AstraLux Sur *iz* data that are consistent (within small amounts) with that information and the 2MASS PSC also points in the same direction. Simbad, however, incorrectly refers to the western component as B when it is really A (the brightest). Crampton (1971) classified the system as O8.5. We were able to separate the A (western) and B (eastern) components with GOSSS. HDE 329 100 A is an O star with spectral type O8 V(n) while the B component is an early-B star.

**HDE 326 775 = CPD -41 7848 = ALS 3906.** Vijapurkar & Drilling (1993) classified this star as O7 V. The GOSSS spectral type is O6.5 V(n)((f))z. We placed the nearby Tyc 7877-01317-1 on the slit and found it is a K star.

**ALS 18 769 = C1715-387-16 = HM 1-16.** To our knowledge, this star in the open cluster Havlen-Moffat 1 has never received a spectral classification. We observed it with GOSSS and determined its spectral type to be O6 II(f), adding another O star to the known Galactic sample.

**HDE 323 110 = ALS 4103.** Vijapurkar & Drilling (1993) classified this star as B0 IIIne. The GOSSS spectral type is ON9 Ia and is discussed in more detail in Walborn et al. (2016). To our knowledge this object had never been classified as an O star.

**Tyc 7370-00460-1 = 2MASS J17181540-3400061.** Gvaramadze et al. (2011) classified

this star as O6.5:. The GOSSS spectral type is O6 V((f)) + O8 V and we caught the system with a  $\Delta v$  of  $\sim 500$  km/s. To our knowledge, this system had not been characterized as an SB2 before.

**ALS 19 693 = [N78] 51.** Lortet et al. (1984) classified this star as O7: V. The GOSSS spectral type is O6 Vn((f)).

**Pismis 24-15 = ALS 17 700 = [N78] 46.** Massey et al. (2001) classified this star as O8 V. The GOSSS spectral type is O7.5 Vz.

**ALS 19 692 = [N78] 49.** Lortet et al. (1984) classified this star as O7: V. The GOSSS spectral type is O5.5 IV((f)).

### 3.3. Spectral classification errors

One of the findings of GOSSS has been that the number of classification errors related to O stars in the literature is quite large. In Maíz Apellániz et al. (2013), we showed that the percentage of false positives (stellar systems erroneously classified as O type) in the GOSSS sample observed so far was 24.9%. Since then, the number has risen above 30% because, in general, dim stars have more uncertain classifications than bright ones and as GOSSS progresses we are moving (on average) into higher magnitude values (see below).

The majority of the false positives turn out to be B stars, which is expected given the spectroscopic and photometric similitudes between O and B stars. However, some of the false positives are egregious mistakes, since they turn out to be of A-K type. Those cases are sometimes caused by identification errors (the spectral type corresponds to a different star) or by photometric classifications reported as spectral types.

We want to especially warn the reader about some of the results given by SIMBAD. The spectral classifications there are of highly variable quality. Furthermore, some are “legacy classifications”, which have been in SIMBAD before a reference was required and, as a result, cannot be traced back to a source. SIMBAD classifications are corrected from time to time but some of the egregious false positives mentioned here are still there at the time of this writing. On the other

hand, we have seen some of them fixed in the last two years.

We show in Fig. 3 the spectrograms of the eleven egregious false positives reported here. The corresponding spectral types and notes are listed in Table 6. A preliminary version of this information was given by Maíz Apellániz et al. (2015c). In future papers we will present the spectrograms of additional false positives.

## 4. Analysis

In this paper we have added 142 O-type systems to the GOSSS sample, raising the total number to 590. Here we analyze some statistics and discuss the status and future of the project.

- Twenty out of the 142 O-type systems (14%) are first-time spectral classifications as O. Some of those had prior low-quality photometric classifications. As a comparison, a smaller number (18) of new O-type systems were found in papers I+II but the significantly larger sample there (448) yields a lower 4%. The percentage difference between papers is expected, as papers I+II were dominated by the brightest and better studied O stars, leaving less room for new discoveries. Indeed, we expect that future GOSSS papers will include an even larger fraction of new O stars.
- We have also discovered eleven new O-type SB2 systems<sup>5</sup>, of which six have O companions (O+O) and five have B companions (O+B), and a new SB3 system (O+O+B). We should point out that for most of the stars in this paper we have only obtained one epoch and that the GOSSS spectral resolution only allows for the detection of SB2 systems with large velocity differences. Therefore, we strongly suspect that there are still many hidden spectroscopic binaries in this paper’s sample. The new SB2 and SB3 systems are being followed up (with GOSSS and in some cases with our high-spectral-resolution projects OWN, CAFÉ-BEANS,

<sup>5</sup>Twelve if you count the recently published system LS III +461 11, whose SB2 nature was also revealed by GOSSS (Maíz Apellániz et al. 2015b).

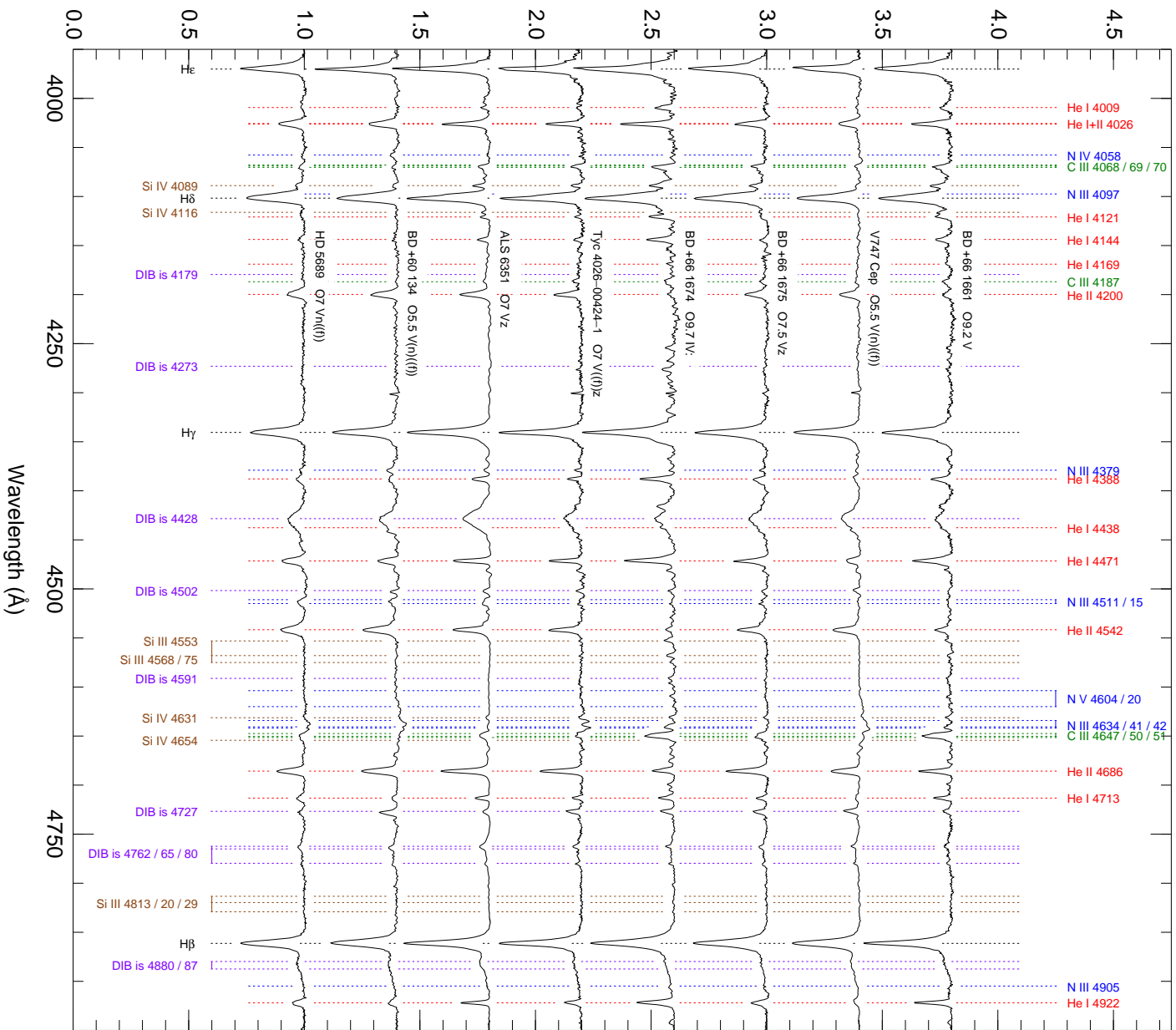


Fig. 2.— (continued).

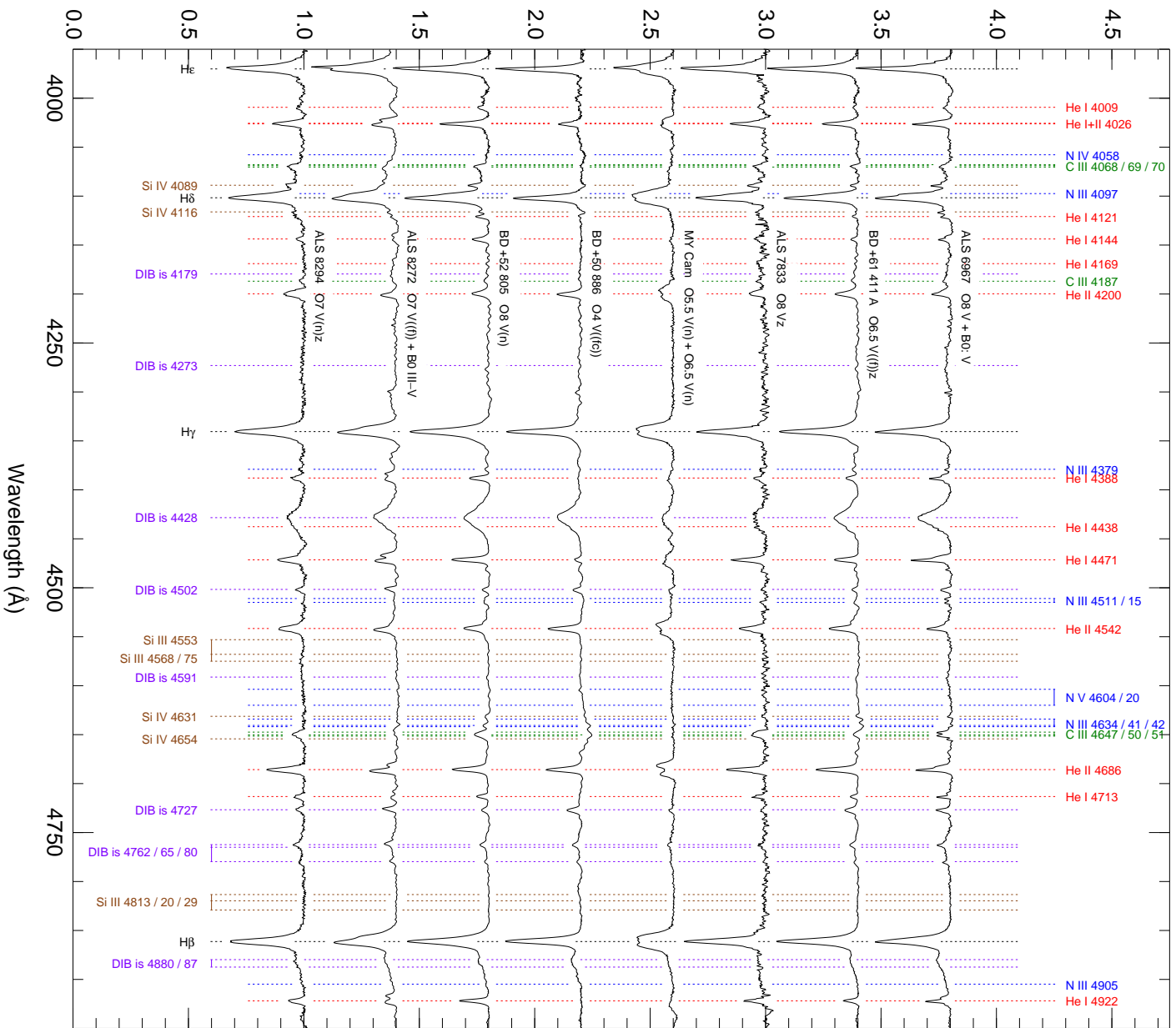


Fig. 2.— (continued).

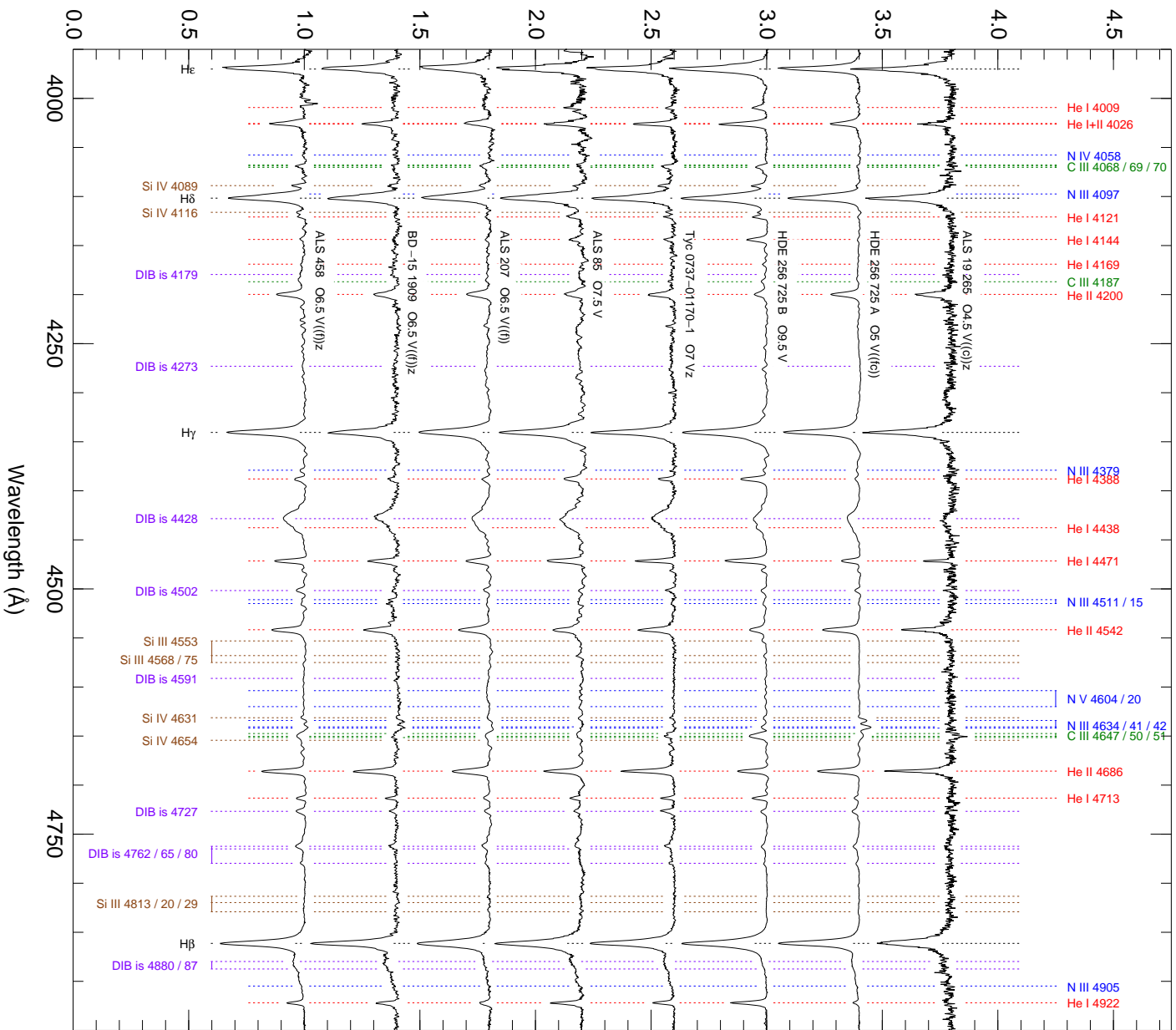


Fig. 2.—(continued).

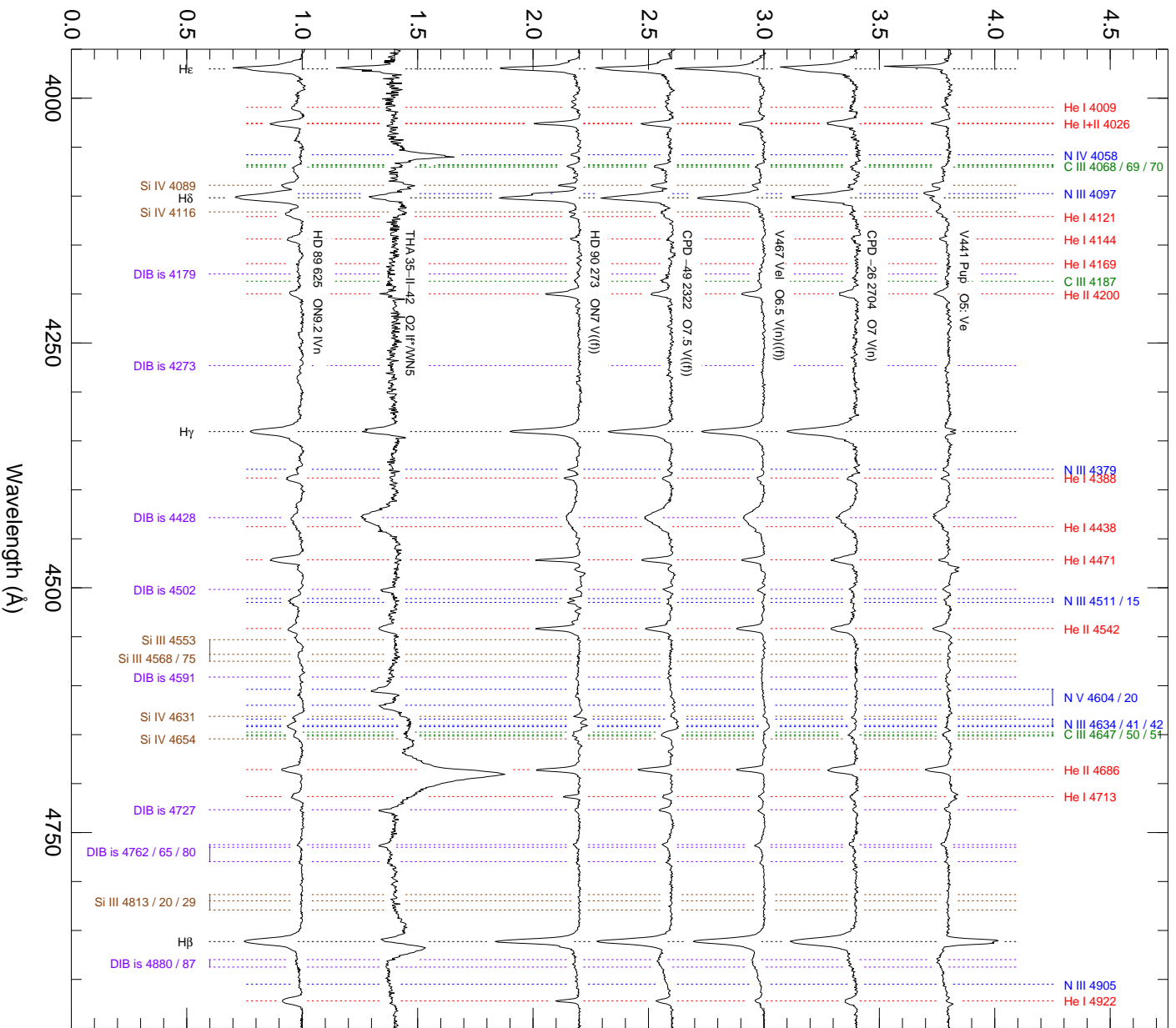


Fig. 2.—(continued).



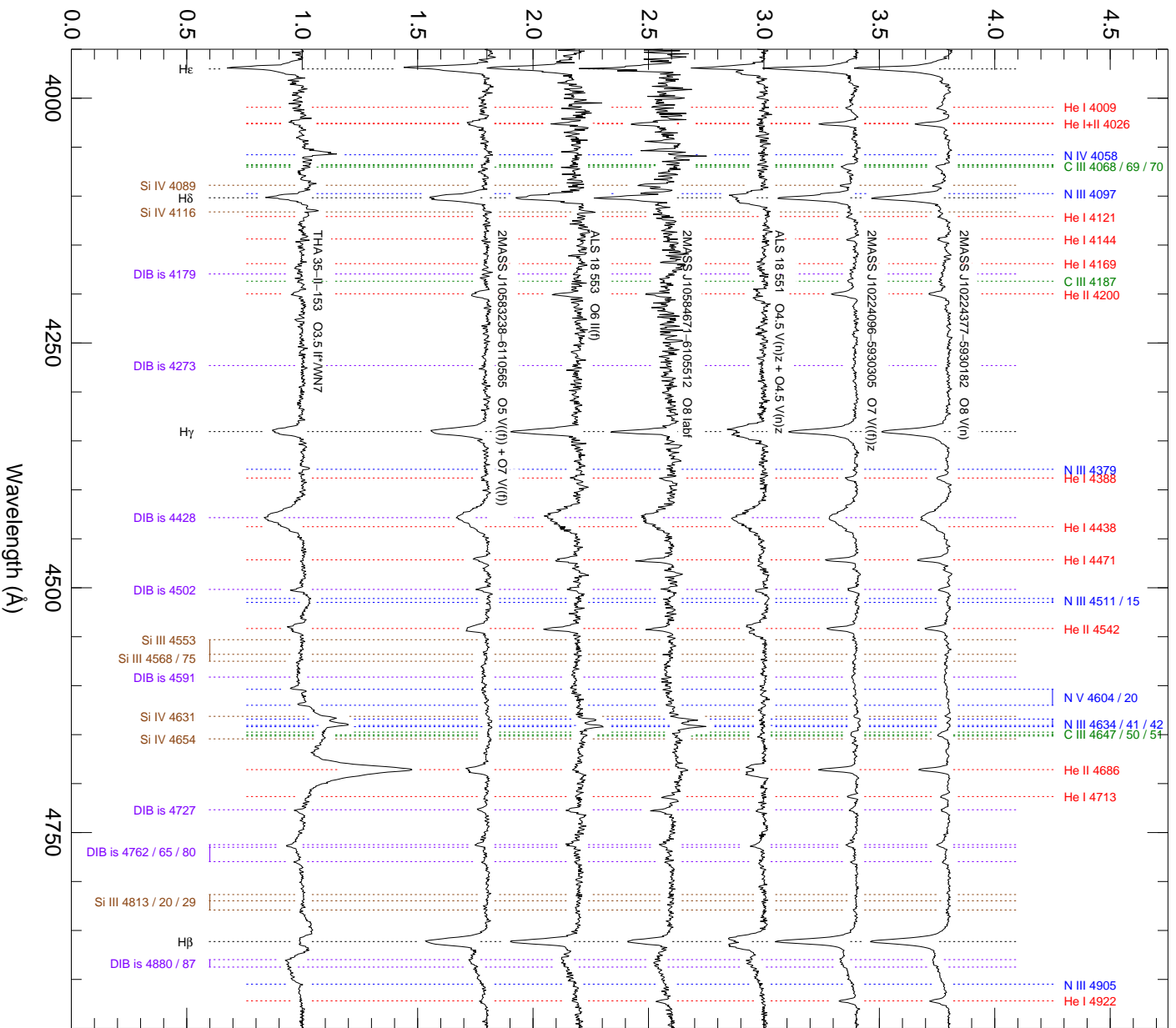


Fig. 2.— (continued).

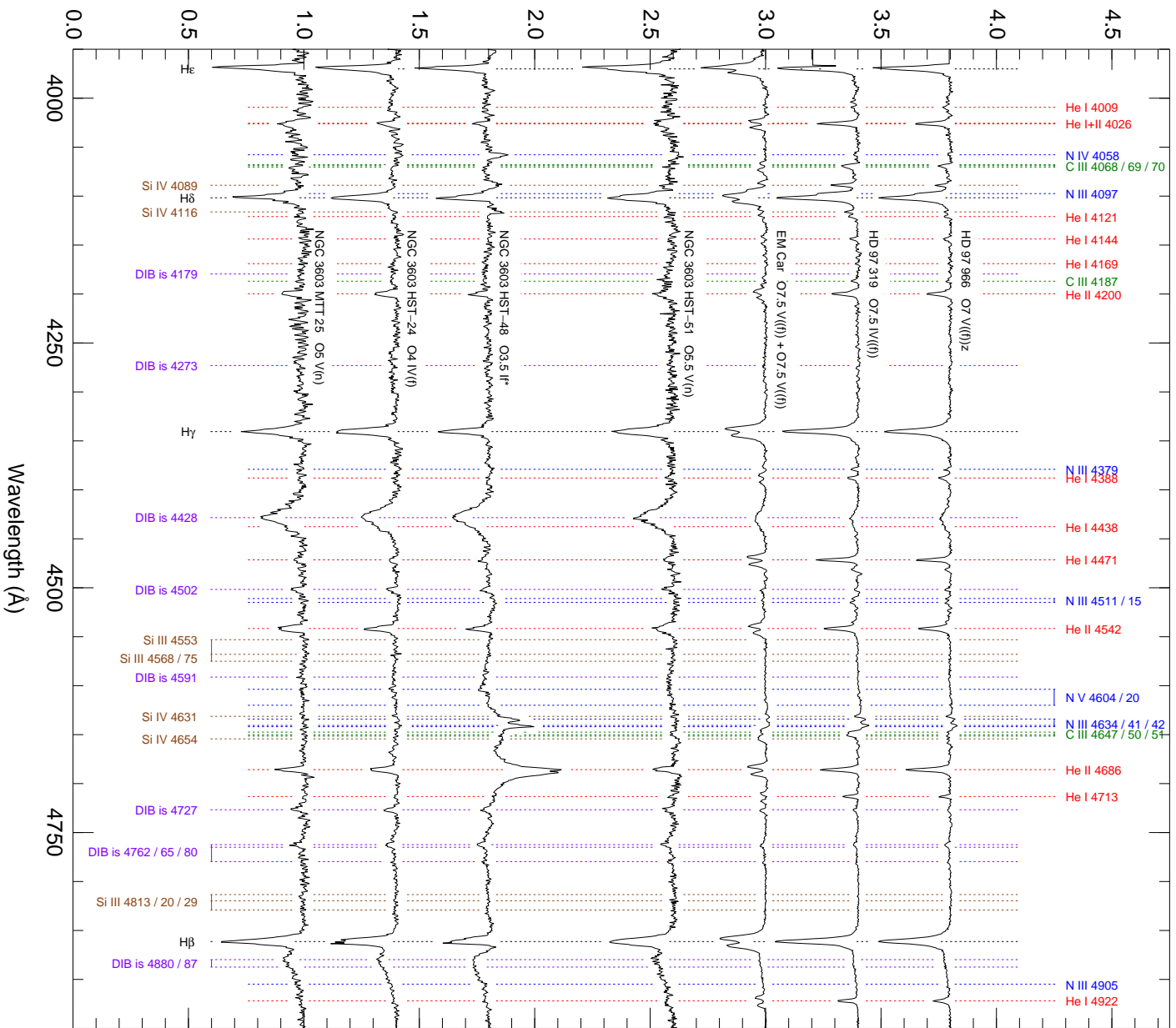


Fig. 2.— (continued).

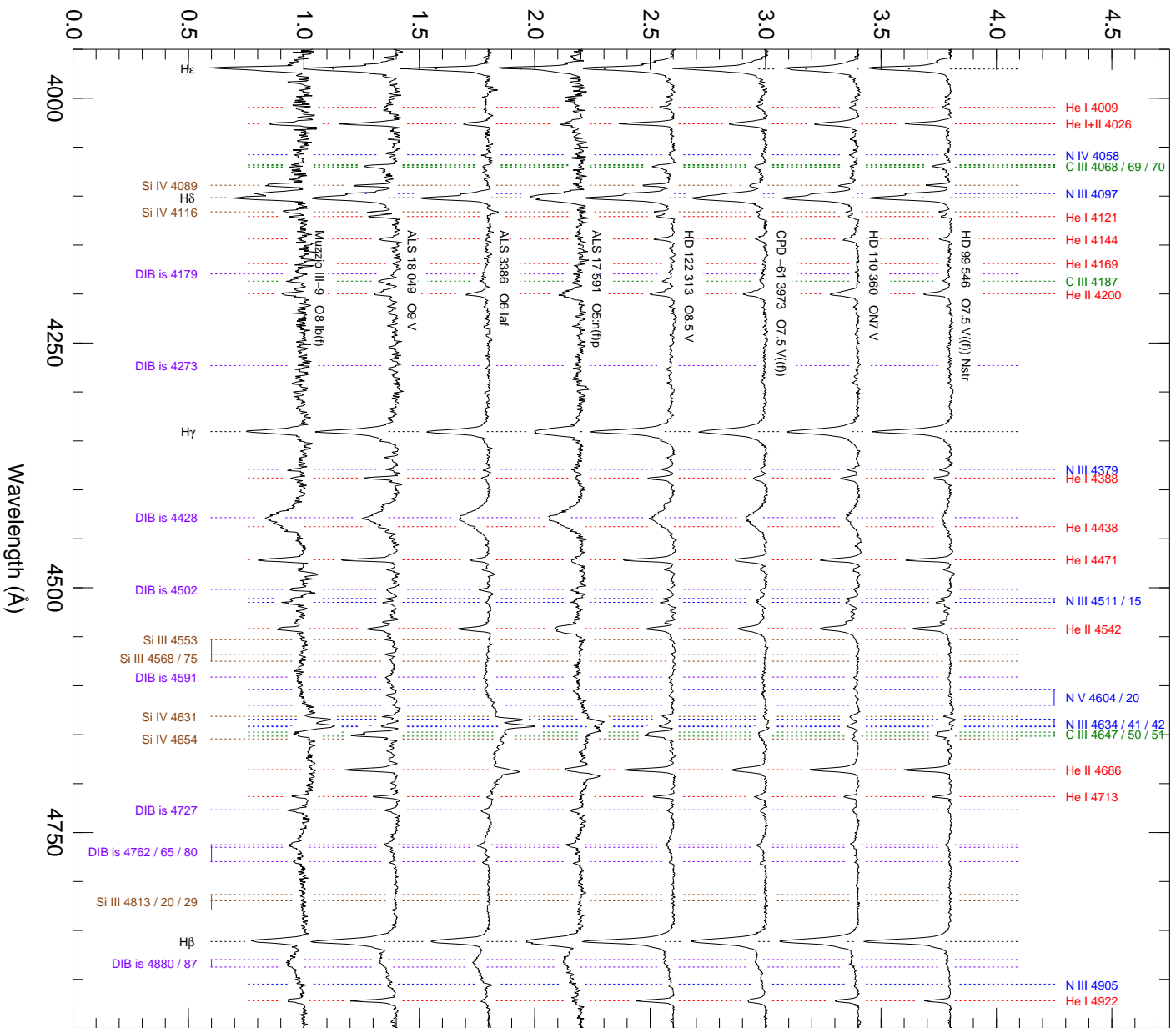


Fig. 2.— (continued).

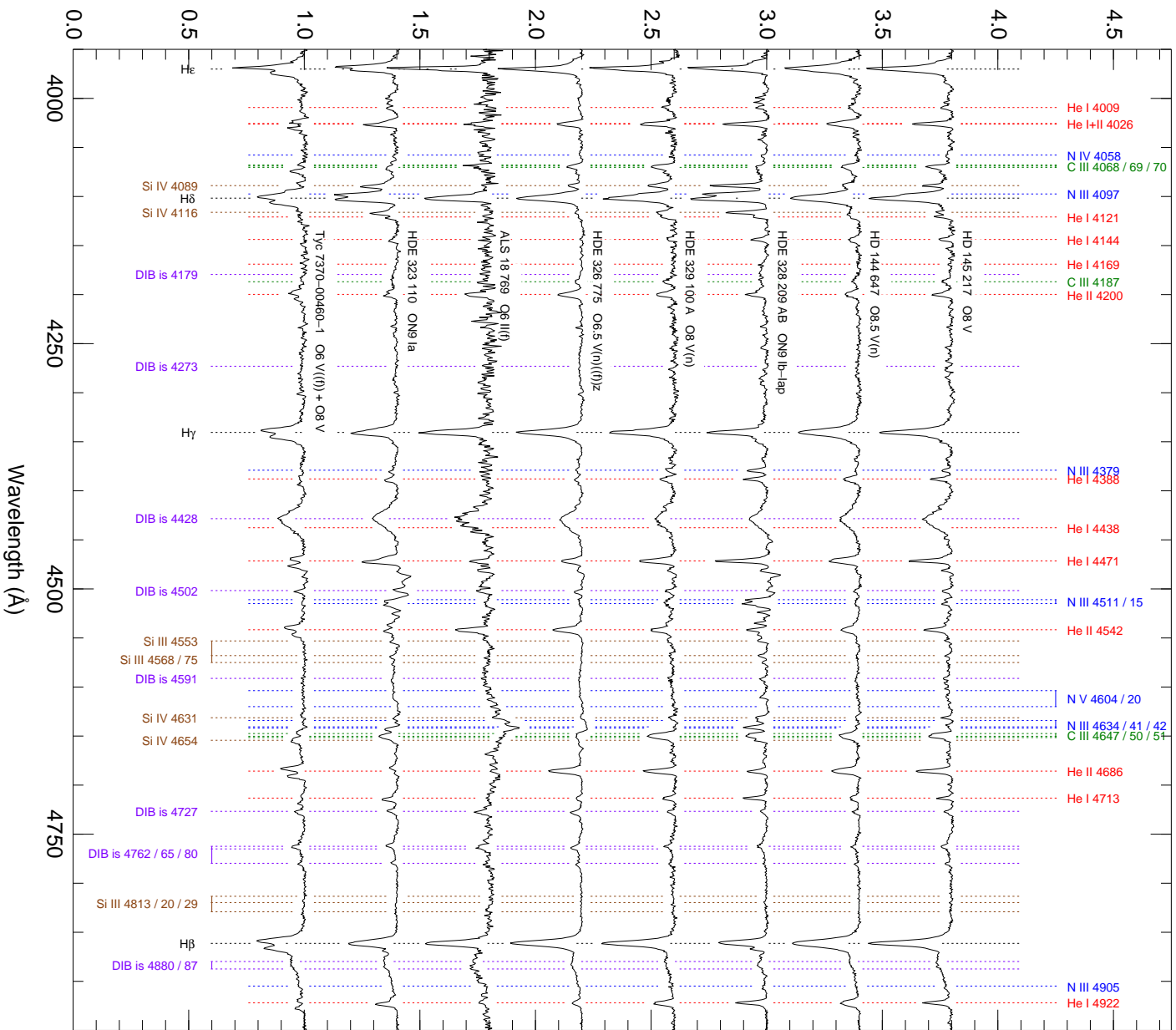


Fig. 2.— (continued).

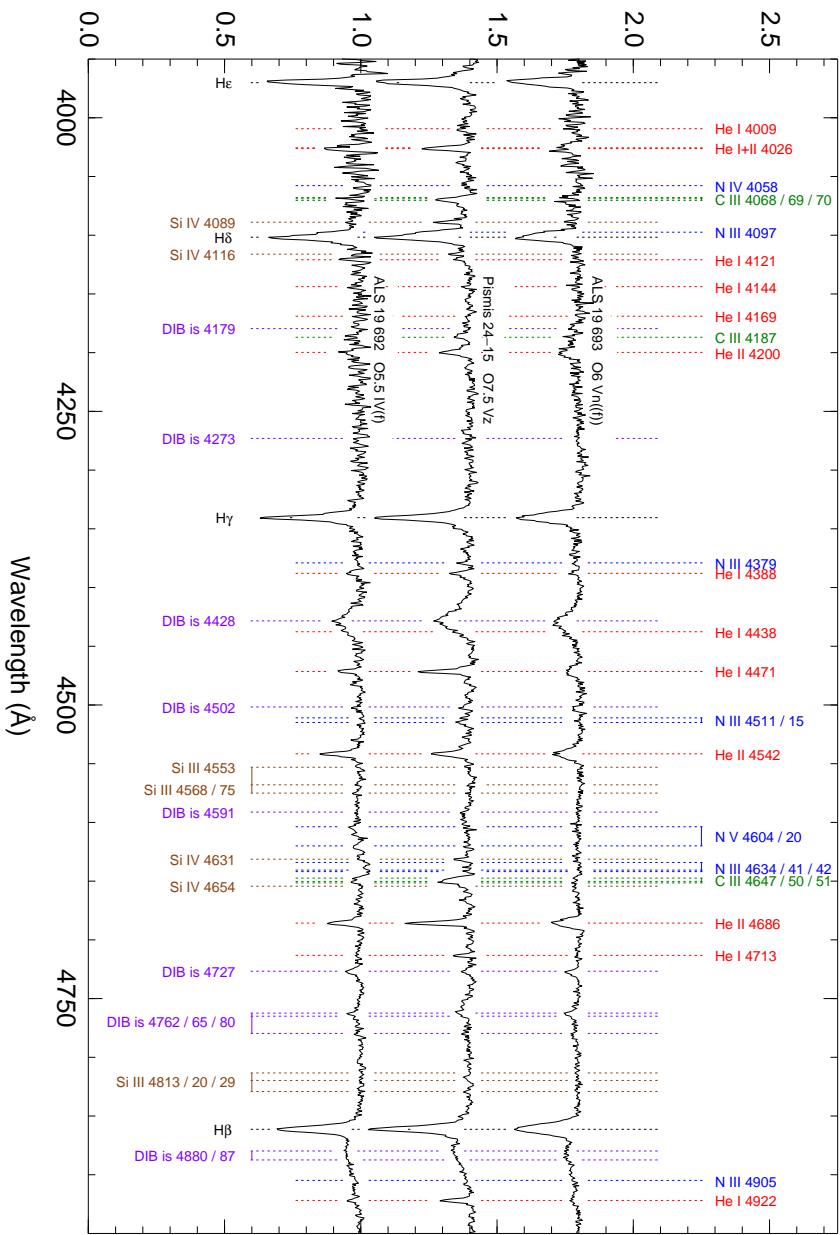


Fig. 2.— (continued).

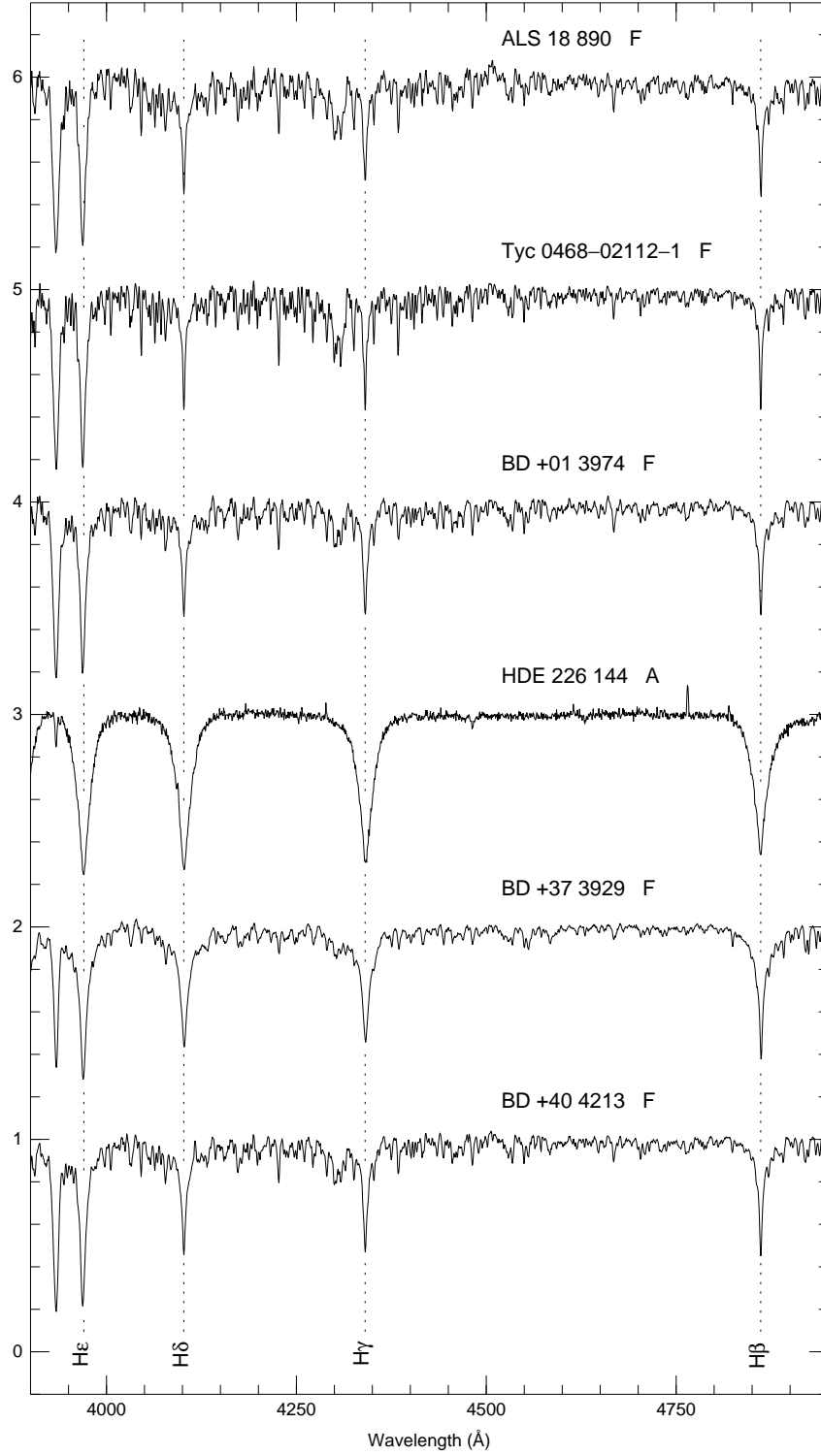


Fig. 3.— Spectrograms for late-type stars erroneously classified as O stars. The targets are sorted by GOS ID. The spectral type is given after the name. [See the electronic version of the journal for a color version of this figure.]

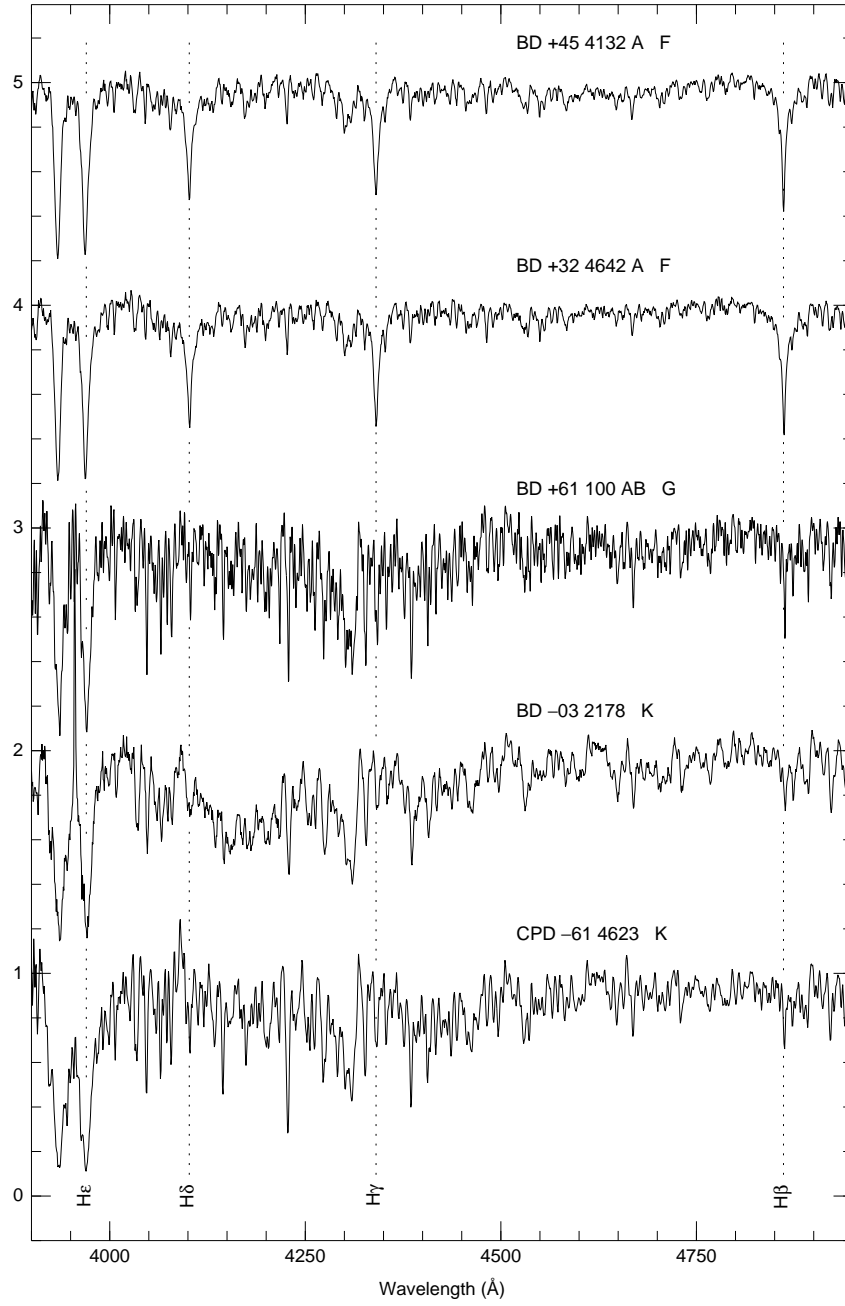


Fig. 3.— (continued).

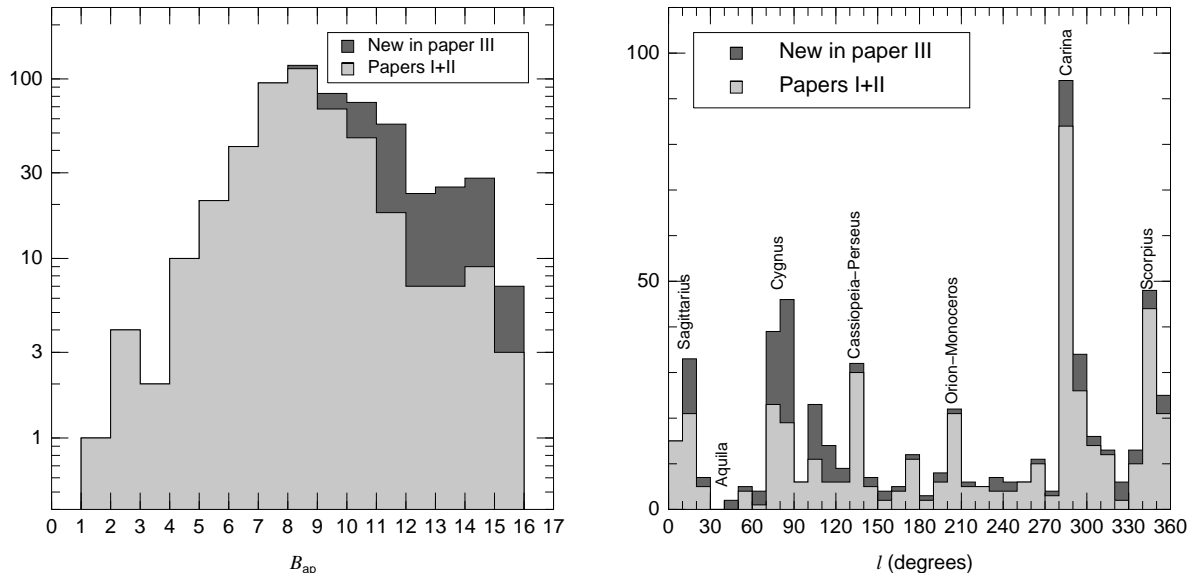


Fig. 4.— [left]  $B_{ap}$  and [right]  $l$  histograms for the GOSSS new sample in this paper and in papers I and II.

IACOB, and NoMaDS) to obtain their orbits.

- Figure 4 [left] shows the  $B_{ap}$  distribution of the previous and new samples. As expected, all new stars have  $B_{ap} > 8$ , so our previous claim that the papers I+II sample was complete to  $B_{ap}=8$  is still valid. Our initial goal for this paper was to concentrate on the  $B_{ap} = 8-11$  magnitude range but we could not follow that path due to the technical problems of the Albireo spectrograph at the 1.5 m OSN telescope and the idiosyncrasies of some time allocation committees. Strangely enough, in the last years we have found easier to get observing time for dim stars than for bright ones (even though we have tried both). As a result, we still have many stars to observe in the  $B_{ap} = 8-11$  magnitude range, as it is readily apparent when comparing Fig. 4 [left] with Fig. 7 in Maíz Apellániz et al. (2013). We expect to reverse the situation in the next years, as one of the ultimate goals of GOSSS is to obtain the massive-star IMF in the solar neighborhood.
- Figure 4 [right] shows the  $l$  distribution of the previous and new samples. Some of the

features of that plot are real, such as the well known prevalence of some regions of the Galactic plane (Carina and Cygnus are the two areas that dominate the O-star population in the solar neighborhood) and the strong effect of foreground extinction in others (the Aquila rift being the most clear one). Others are partially created by the different amounts of time we have had allocated in the two hemispheres (so far we have had more time in the north than in the south). It is interesting that the dichotomy between the first and fourth quadrants on one hand (toward the Galactic center) and the second and third on the other (away from it) is already visible, with more stars in the first case due to the larger stellar densities and disk depths. That is possible despite our easier telescope access towards the first three quadrants (those completely or partially visible from the northern hemisphere), indicating the strength of the effect.

- We have several additional hundreds of non-published stars with preliminary O-type classifications already observed with GOSSS and we are currently observing at a rate of  $\sim 200$  new ones per year. Our plan is to pub-



lish new blocks of O stars similar in quantity to the one in this paper every approximately 2 years. At this rate, we expect to run out of O stars with  $B_{\text{ap}} < 14$  to observe in the second and third quadrants in a time scale of 2-3 years. Doing so in the first and fourth quadrants should take significantly longer.

- Besides the developments derived from GOSSS associated with the stellar properties (e.g. Arias et al. 2016), we would like to point out that GOSSS is turning out to be a treasure trove to study the ISM (Penadés Ordaz et al. 2011, 2013; Maíz Apellániz 2013a, 2015; Maíz Apellániz et al. 2014a, 2015c). We are currently working on an analysis of the extinction type and distribution based on the sample presented in the three GOSSS papers.
- GOSSS (including some of the new additions here) is being used as the basis for the sample selection for the OWN (Barbá et al. 2010) and IACOB (Simón-Díaz et al. 2011) projects. The high-resolution spectra obtained there will be used to derive the properties of the likely single O stars through their quantitative analysis.

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TABLE 3

STARS IN PAPERS I+II WITH RECENTLY DISCOVERED BRIGHT COMPANIONS UNRESOLVED IN THE GOSSS SPECTRA.

Name	GOSSS ID	Ref.	New	Comments
9 Sgr AB	006.01−01.20_01	S14	B	
HD 168 112 AB	018.44+01.62_01	S14	B	
HD 14 633 AaAb	140.78−18.20_01	A15	Ab	
HD 46 966 AaAb	205.81−00.55_01	S14,A15	Ab	
$\sigma$ Ori AaAbB	206.82−17.34_01	H13,S13c	Ab	B was already in paper I, S15 obtain a more accurate spectroscopic orbit.
HD 54 662 AB	224.17−00.78_01	S14	B	
CPD −35 2105 AaAbB	253.64−00.45_01	A15	Ab	B was already considered in paper II.
HD 75 759 AB	262.80+01.25_01	S14	B	
CPD −47 2963 AB	267.98−01.36_01	S14	B	
HD 93 160 AB	287.44−00.59_01	S14	B	WDS 10441−5935 CaCb, HD 93 161 AB is WDS 10441−5935 AB.
QZ Car AaAc	287.67−00.94_01	S14	Ac	We use the WDS component nomenclature instead of that of the paper.
HD 93 222 AB	287.74−01.02_01	S14	B	
HD 96 670 AB	290.20+00.40_01	S14	B	
HD 97 253 AB	290.79+00.09_01	S14	B	
HD 101 190 AaAb	294.78−01.49_01	S14	Ab	
HD 101 131 AB	294.78−01.62_01	S14	B	
HD 101 545 AaAb	294.88−00.81_01	S14	Ab	A separate spectrum for the B component was obtained in paper II.
HD 101 413 AB	295.03−01.71_01	S14	B	
HD 123 590 AB	311.95−01.00_01	S14	B	
HD 124 314 AaAb	312.67−00.42_01	S14	Ab	A separate spectrum for the BaBb component was obtained in paper II.
HD 125 206 AB	313.45−00.03_01	S14	B	
$\delta$ Cir AaAbAc	319.69−02.91_01	S14	Ac	AaAb is spatially unresolved but is catalogued that way in the WDS.
HD 148 937 AaAb	336.37−00.22_01	S14	Ab	
HD 150 135 AaAb	336.71−01.57_01	S14	Ab	WDS 6413−4846 CaCb, HD 150 136 AaAb is WDS 6413−4846 AaAb.
HD 150 136 AaAb	336.71−01.57_02	S13a,S13b	Ab	The inner pair is still unresolved.
HD 151 003 AB	342.72+02.41_01	S14	B	
HD 152 233 AaAb	343.48+01.22_01	S14	Ab	WDS 16540−4148 FaFb, HD 152 234 A is WDS 16540−4148 A.
HD 152 314 AaAb	343.52+01.14_01	S14	Ab	
HD 152 247 AaAb	343.61+01.30_01	S14	Ab	
HD 152 246 AaAb	344.03+01.67_01	S14	Ab	
HD 152 623 AaAbB	344.62+01.61_01	S14	Ab	B was already considered in paper II.
HD 156 738 AB	351.18+00.48_01	S14	B	
HD 155 806 AB	352.59+02.87_01	S14	B	

References. — A15: Aldoretta et al. (2015), H13: Hummel et al. (2013), S13a: Sana et al. (2013), S13b: Sánchez-Bermúdez et al. (2013), S13c: Schaefer (2013), S14: Sana et al. (2014), S15: Simón-Díaz et al. (2015)

TABLE 4  
SPECTRAL RECLASSIFICATIONS FOR STARS ALREADY PRESENT IN PAPERS I AND II.

Name	GOSSS ID	RA (J2000)	dec (J2000)	ST	LC	Qual.	Second.
HD 164 536	GOS 005.96−00.91_01	18:02:38.619	−24:15:19.39	O7.5	V	(n)	...
9 Sgr AB	GOS 006.01−01.20_01	18:03:52.446	−24:21:38.64	O4	V	((f))	...
HD 165 052	GOS 006.12−01.48_01	18:05:10.551	−24:23:54.85	O6	V	z	O8 Vz
HD 168 075	GOS 016.94+00.84_01	18:18:36.043	−13:47:36.46	O6.5	V	((f))	...
HD 168 076 AB	GOS 016.94+00.84_02	18:18:36.421	−13:48:02.38	O4	IV	(f)	...
HD 168 112 AB	GOS 018.44+01.62_01	18:18:40.868	−12:06:23.39	O5	IV	(f)	...
HD 173 010	GOS 023.73−02.49_01	18:43:29.710	−09:19:12.61	O9.7	Ia+	var	...
HDE 344 784 A	GOS 059.40−00.15_01	19:43:10.970	+23:17:45.38	O6.5	V	((f))z	...
HD 192 281	GOS 077.12+03.40_01	20:12:33.121	+40:16:05.45	O4.5	IV	(n)(f)	...
HDE 229 232 AB	GOS 077.40+00.93_01	20:23:59.183	+39:06:15.27	O4	V:	n((f))	...
HD 191 978	GOS 077.87+04.25_01	20:10:58.281	+41:21:09.91	O8	V	...	...
HD 207 198	GOS 103.14+06.99_01	21:44:53.278	+62:27:38.04	O8.5	II	((f))	...
BD +60 513	GOS 134.90+00.92_01	02:34:02.530	+61:23:10.87	O7	V	n	...
HD 14 434	GOS 135.08−03.82_01	02:21:52.413	+56:54:18.03	O5.5	IV	nn(f)p	...
HD 17 520 A	GOS 137.22+00.88_01	02:51:14.434	+60:23:09.97	O8	V	...	...
HD 35 619	GOS 173.04−00.09_01	05:27:36.147	+34:45:18.96	O7.5	V	((f))	...
HD 36 879	GOS 185.22−05.89_01	05:35:40.527	+21:24:11.72	O7	V	(n)((f))	...
HD 48 099	GOS 206.21+00.80_01	06:41:59.231	+06:20:43.54	O5.5	V	((f))z	O9 V
HD 46 485	GOS 206.90−01.84_01	06:33:50.957	+04:31:31.62	O7	V	((f))n var?	...
HD 48 279 A	GOS 210.41−01.17_01	06:42:40.548	+01:42:58.23	O8.5	V	Nstr var?	...
HD 64 315 AB	GOS 243.16+00.36_01	07:52:20.284	−26:25:46.69	O5.5	V	...	O7 V
CPD -47 2962	GOS 268.00−01.38_01	08:57:51.661	−47:45:43.94	O7	V	((f))	...
HD 92 206 B	GOS 286.22−00.17_02	10:37:22.957	−58:37:23.04	O6	V	((f))	...
HD 92 206 C	GOS 286.22−00.18_01	10:37:18.627	−58:37:41.73	O8	V	(n)z	B0: V
ALS 15 204	GOS 287.40−00.63_02	10:43:41.237	−59:35:48.18	O7.5	V	z	O9: V
HD 93 129 B	GOS 287.41−00.57_02	10:43:57.638	−59:32:53.50	O3.5	V	((f))z	...
HD 93 250 AB	GOS 287.51−00.54_01	10:44:45.027	−59:33:54.67	O4	IV	(fc)	...
V572 Car	GOS 287.59−00.69_01	10:44:47.307	−59:43:53.23	O7.5	V	(n)	B0 V(n)
CPD -59 2591	GOS 287.60−00.75_01	10:44:36.688	−59:47:29.63	O8	V	z	B0.5: V:
CPD -59 2626 AB	GOS 287.63−00.69_01	10:45:05.794	−59:45:19.60	O7.5	V	(n)	...
HD 93 343	GOS 287.64−00.68_01	10:45:12.217	−59:45:00.42	O8	V	...	...
HD 93 146 A	GOS 287.67−01.05_01	10:44:00.158	−60:05:09.86	O7	V	((f))	...
V662 Car	GOS 287.71−00.71_01	10:45:36.318	−59:48:23.37	O5	V	(n)z	B0: V
HD 93 222 AB	GOS 287.74−01.02_01	10:44:36.250	−60:05:28.88	O7	V	((f))	...
HDE 305 525	GOS 287.79−00.71_01	10:46:05.704	−59:50:49.45	O5.5	V	((f))z	O7.5 V + B
TU Mus	GOS 294.81−04.14_01	11:31:10.927	−65:44:32.10	O8	V	(n)	B0 V(n)
δ Cir AaAbAc	GOS 319.69−02.91_01	15:16:56.894	−60:57:26.12	O7	IV	((f))	B
CPD -41 7721 A	GOS 343.44+01.17_01	16:54:06.709	−41:51:07.21	O9.7	V:	(n)	...
V1034 Sco	GOS 343.48+01.15_01	16:54:19.845	−41:50:09.36	O9.2	IV	...	B1: V
HD 152 623 AaAbB	GOS 344.62+01.61_01	16:56:15.026	−40:39:35.76	O7	V	(n)((f))	...
HD 156 292	GOS 345.35−03.08_01	17:18:45.814	−42:53:29.92	O9.7	III	...	B
ALS 18 770	GOS 348.71−00.79_01	17:19:00.800	−38:49:23.13	O7	V	((f))	...
HDE 319 703 A	GOS 351.03+00.65_01	17:19:46.156	−36:05:52.34	O7	V	((f))	O9.5 V
HD 155 806 AB	GOS 352.59+02.87_01	17:15:19.247	−33:32:54.30	O7.5	V	((f))(e)	...
HD 158 186	GOS 355.91+01.60_01	17:29:12.925	−31:32:03.44	O9.2	V	...	B1: V

NOTE.—*GOSSS ID* is the identification for each star with “GOS” standing for “Galactic O Star”.

TABLE 5  
SPECTRAL CLASSIFICATIONS FOR NEW GOSSS STARS.

Name	GOSSS ID	RA (J2000)	dec (J2000)	ST	LC	Qual.	Second.
ALS 19618	GOS 015.07−00.70_01	18:20:34.493	−16:10:11.85	O4	V	(n)((fc))	...
BD -16 4826	GOS 015.26−00.73_01	18:21:02.231	−16:01:00.94	O5.5	V	((f))z	...
ALS 4923	GOS 015.70−00.06_01	18:19:28.435	−15:18:46.27	O8.5	V	...	O8.5 V
ALS 4626	GOS 015.88+04.22_01	18:04:17.885	−13:06:13.76	ON6	V	((f))	...
BD -14 5014	GOS 016.65−00.35_01	18:22:22.310	−14:37:08.46	O7.5	V	(n)((f))	...
V479 Sct	GOS 016.88−01.29_01	18:26:15.045	−14:50:54.33	ON6	V	((f))z	...
BD -14 5040	GOS 016.90−01.12_01	18:25:38.896	−14:45:05.70	O5.5	V	(n)((f))	...
HD 168 137 AaAb	GOS 016.97+00.76_01	18:18:56.189	−13:48:31.08	O8	V	z	...
ALS 15 360	GOS 017.00+00.87_01	18:18:37.494	−13:43:39.39	O7	V	((f))z	...
HD 168 504	GOS 017.03+00.35_01	18:20:34.096	−13:57:15.75	O7.5	V	(n)z	...
ALS 4880	GOS 018.32+01.87_01	18:17:33.672	−12:05:42.80	O6	V	((f))	...
HD 168 461	GOS 018.57+01.25_01	18:20:17.179	−12:10:19.19	O7.5	V	((f)) Nstr	...
BD -10 4682	GOS 020.24+01.01_01	18:24:20.651	−10:48:34.29	O7	V	n((f))	...
BD -04 4503	GOS 026.85+01.34_01	18:35:32.534	−04:47:55.39	O7	V	...	...
HD 175 514	GOS 041.71+03.38_01	18:55:23.124	+09:20:48.07	O7	V	(n)((f))z	B
ALS 18 929	GOS 042.79+10.57_01	18:31:01.379	+13:30:12.85	O9.7	...	...	...
HDE 344 777	GOS 059.41+00.11_01	19:42:11.470	+23:26:00.52	O7.5	V	z	...
HDE 344 758	GOS 060.17+00.63_01	19:41:52.721	+24:20:51.07	O8.5	V	(n)((f))	...
HDE 338 931	GOS 061.19−00.14_01	19:47:02.739	+24:50:55.57	O6	III	(f)	...
HDE 338 916	GOS 061.47+00.38_01	19:45:42.114	+25:21:16.45	O7.5	V	z	...
HDE 227 465	GOS 070.73+01.21_01	20:04:27.225	+33:42:18.40	O7	V	((f))	...
HDE 227 018	GOS 071.58+02.87_01	19:59:49.103	+35:18:33.53	O6.5	V	((f))z	...
HDE 227 245	GOS 072.17+02.62_01	20:02:21.713	+35:40:29.84	O7	V	((f))z	...
HDE 228 779	GOS 073.18−00.51_01	20:17:54.189	+34:49:02.03	O9	Iab	...	...
HDE 228 854	GOS 074.54+00.20_01	20:18:47.219	+36:20:26.08	O6	IV	n var	O5 Vn var
ALS 18 707	GOS 074.76+00.62_01	20:17:41.846	+36:45:26.42	O6.5	V	((f))z	...
HD 193 682	GOS 075.92+00.82_01	20:20:08.937	+37:49:51.30	O4.5	IV	(f)	...
HD 193 595	GOS 076.86+01.62_01	20:19:31.327	+39:03:26.21	O7	V	((f))	...
BD +36 4145	GOS 077.45−02.02_01	20:36:18.208	+37:25:02.79	O8.5	V	(n)	...
HDE 229 202	GOS 078.19+01.63_01	20:23:22.842	+40:09:22.52	O7.5	V	(n)((f))	...
ALS 11 355	GOS 078.29+00.78_01	20:27:17.572	+39:44:32.55	O8	V	(n)((f))	...
HD 194 649 AB	GOS 078.46+01.35_01	20:25:22.124	+40:13:01.07	O6.5	V	((f))	...
HDE 228 759	GOS 079.01+03.62_01	20:17:07.539	+41:57:26.51	O6.5	V	(n)((f))z	...
LS III+41 14	GOS 079.01+03.63_01	20:17:05.515	+41:57:46.89	O9.5	V	(n)	...
BD +40 4179	GOS 079.03+01.21_01	20:27:43.617	+40:35:43.53	O8	V	z	...
Cyg OB2-B17	GOS 079.84+01.16_01	20:30:27.302	+41:13:25.31	O6	Ia	f	O9: Ia:
Cyg OB2-A24	GOS 080.03+00.30_01	20:34:44.106	+40:51:58.50	O6.5	III	(f)	...
2MASS J20315961+4114504	GOS 080.03+00.94_01	20:31:59.613	+41:14:50.50	O7.5	V	z	...
Cyg OB2-A11	GOS 080.08+00.85_01	20:32:31.543	+41:14:08.21	O7	Ib	(f)	...
ALS 15 108 AB	GOS 080.11+00.67_01	20:33:23.460	+41:09:13.02	O6	IV	((f))	...
Cyg OB2-5 B	GOS 080.12+00.91_02	20:32:22.489	+41:18:19.45	O6.5	Iab	fp	...
ALS 15 134	GOS 080.14+00.68_01	20:33:26.749	+41:10:59.51	O8	V	z	...
Cyg OB2-22 D	GOS 080.14+00.74_02	20:33:10.115	+41:13:10.10	O9.5	V	n	...
ALS 15 144	GOS 080.15+00.79_01	20:32:59.643	+41:15:14.67	O9.7	III	(n)	...
ALS 15 119	GOS 080.23+00.71_01	20:33:37.001	+41:16:11.30	O9.5	IV	(n)	...
Cyg OB2-17	GOS 080.24+00.90_01	20:32:50.011	+41:23:44.71	O8	V	...	...
Cyg OB2-16	GOS 080.24+00.94_01	20:32:38.575	+41:25:13.76	O7.5	IV	(n)	...
Cyg OB2-6	GOS 080.26+00.93_01	20:32:45.447	+41:25:37.50	O8.5	V	(n)	...
ALS 15 115	GOS 080.27+00.81_01	20:33:18.046	+41:21:36.90	O8	V	...	...
ALS 15 111	GOS 080.27+00.88_01	20:32:59.190	+41:24:25.47	O8	V	...	...



TABLE 5—*Continued*

Name	GOSSS ID	RA (J2000)	dec (J2000)	ST	LC	Qual.	Second.
Cyg OB2-27 AB	GOS 080.29+00.66_01	20:33:59.528	+41:17:35.48	O9.7	V	(n)	O9.7 V:(n)
Cyg OB2-73	GOS 080.32+00.60_01	20:34:21.930	+41:17:01.60	O8	V	z	O8 Vz
Cyg OB2-25 A	GOS 080.44+00.91_01	20:33:25.539	+41:33:26.74	O8	V	z	...
Cyg OB2-10	GOS 080.47+00.85_01	20:33:46.111	+41:33:01.05	O9.7	Iab	...	...
ALS 15 125	GOS 080.53+00.80_01	20:34:09.519	+41:34:13.69	O9.5	IV:	...	...
ALS 15 114	GOS 080.54+00.73_01	20:34:29.601	+41:31:45.42	O7.5	V	(n)((f))	...
Cyg OB2-29	GOS 080.55+00.80_01	20:34:13.505	+41:35:03.01	O7.5	V	(n)((f))z	...
BD +43 3654	GOS 082.41+02.33_01	20:33:36.080	+43:59:07.41	O4	I	f	...
BD +45 3216 A	GOS 083.78+03.29_01	20:33:50.366	+45:39:40.95	O5	V	((f))z	...
Bajamar Star	GOS 084.81−00.88_01	20:55:51.255	+43:52:24.67	O3.5	III	(f*)	O8:
LS III+46 12	GOS 084.88+03.78_01	20:35:18.566	+46:50:02.90	O4.5	IV	(f)	...
LS III+46 11	GOS 084.88+03.81_01	20:35:12.642	+46:51:12.12	O3.5	I	f*	O3.5 If*
ALS 11 761	GOS 088.81−01.12_01	21:12:00.455	+46:41:51.31	O9.2	II	...	...
ALS 12 050	GOS 101.08+02.47_01	21:55:15.291	+57:39:45.66	O5	V	((f))	...
BD +55 2722 A	GOS 102.81−00.67_01	22:18:58.629	+56:07:23.47	O8	V	z	...
BD +55 2722 C	GOS 102.81−00.67_02	22:18:59.876	+56:07:18.92	O7	V	(n)z	B
BD +55 2722 B	GOS 102.81−00.67_03	22:18:58.832	+56:07:23.47	O9.5	V	...	...
ALS 12 320	GOS 102.98−00.76_01	22:20:21.783	+56:08:52.21	O7	IV	((f))	...
ALS 12 370	GOS 103.05−01.41_01	22:23:17.417	+55:38:02.31	O6.5	V	nn((f))	...
ALS 12 619	GOS 107.18−00.95_01	22:47:50.595	+58:05:12.39	O7	V	((f))z	...
BD +55 2840	GOS 107.30−02.92_01	22:55:08.492	+56:22:58.88	O7.5	V	(n)	...
ALS 12 688	GOS 107.42−02.87_01	22:55:44.944	+56:28:36.70	O5.5	V	(n)((fc))	B
BD +62 2078	GOS 107.45+05.02_01	22:25:33.579	+63:25:02.62	O7	V	((f))z	...
HD 213 023 A	GOS 107.73+05.20_01	22:26:52.362	+63:43:04.87	O7.5	V	z	...
ALS 12 749	GOS 108.54−02.74_01	23:02:44.556	+57:03:50.21	O9	V	...	...
Sh 2-158 2	GOS 111.53+00.82_01	23:13:30.243	+61:30:10.34	O9.5:	V	...	B0.5: V
Sh 2-158 1	GOS 111.53+00.82_02	23:13:34.435	+61:30:14.73	O3.5	V	((f*))	O9.5: V
BD +60 2635	GOS 115.90−01.16_01	23:53:05.205	+60:54:44.62	O6	V	((f))	...
BD +66 1661	GOS 117.81+05.22_01	23:57:32.603	+67:33:15.28	O9.2	V	...	...
V747 Cep	GOS 118.20+05.09_01	00:01:46.870	+67:30:25.13	O5.5	V	(n)((f))	...
BD +66 1675	GOS 118.21+04.99_01	00:02:10.287	+67:24:32.22	O7.5	V	z	...
BD +66 1674	GOS 118.22+05.01_01	00:02:10.236	+67:25:45.21	O9.7	IV:	...	...
Tyc 4026-00424-1	GOS 118.23+05.01_01	00:02:19.027	+67:25:38.55	O7	V	((f))z	...
ALS 6351	GOS 122.57+00.12_01	00:48:12.548	+62:59:24.84	O7	V	z	...
BD +60 134	GOS 123.50−01.11_01	00:56:14.216	+61:45:36.91	O5.5	V	(n)((f))	...
HD 5689	GOS 123.86+00.75_01	00:59:47.589	+63:36:28.27	O7	V	n((f))	...
ALS 6967	GOS 132.94−01.39_01	02:12:29.974	+59:54:04.12	O8	V	...	B0: V
BD +61 411 A	GOS 133.84+01.17_01	02:26:34.379	+62:00:42.32	O6.5	V	((f))z	...
ALS 7833	GOS 146.25+03.12_01	03:59:07.494	+57:14:11.69	O8	V	z	...
MY Cam	GOS 146.27+03.14_01	03:59:18.290	+57:14:13.72	O5.5	V	(n)	O6.5 V(n)
BD +50 886	GOS 150.60−00.94_01	04:03:20.736	+51:18:52.46	O4	V	((fc))	...
BD +52 805	GOS 151.26+01.79_01	04:18:35.640	+52:51:54.21	O8	V	(n)	...
ALS 8272	GOS 168.75+01.00_01	05:20:00.634	+38:54:43.54	O7	V	((f))	B0 III-V
ALS 8294	GOS 173.61−01.72_01	05:22:39.690	+33:22:18.23	O7	V	(n)z	...
ALS 19 265	GOS 186.10+06.56_01	06:24:59.866	+26:49:19.41	O4.5	V	((c))z	...
HDE 256 725 A	GOS 192.32+03.36_01	06:25:01.300	+19:50:56.07	O5	V	((fc))	...
HDE 256 725 B	GOS 192.32+03.36_02	06:25:01.900	+19:50:54.52	O9.5	V	...	...
Tyc 0737-01170-1	GOS 201.61+01.64_01	06:36:29.003	+10:49:20.73	O7	V	z	...
ALS 85	GOS 218.82−04.57_01	06:45:48.800	−07:18:46.63	O7.5	V	...	...
ALS 207	GOS 231.49−04.40_01	07:09:55.206	−18:30:07.88	O6.5	V	((f))	...

TABLE 5—*Continued*

Name	GOSSS ID	RA (J2000)	dec (J2000)	ST	LC	Qual.	Second.
BD -15 1909	GOS 232.31+01.94_01	07:34:58.463	−16:14:23.22	O6.5	V	((f))z	...
ALS 458	GOS 234.28−00.50_01	07:30:01.272	−19:08:34.98	O6.5	V	((f))z	...
V441 Pup	GOS 240.28−04.05_01	07:28:53.586	−26:06:28.89	O5:	V	e	...
CPD -26 2704	GOS 243.14+00.44_01	07:52:36.593	−26:22:41.99	O7	V	(n)	...
V467 Vel	GOS 265.20−02.18_01	08:43:49.809	−46:07:08.78	O6.5	V	(n)((f))	...
CPD -49 2322	GOS 271.65−00.70_01	09:15:52.787	−50:00:43.82	O7.5	V	((f))	...
HD 90 273	GOS 284.18−00.25_01	10:23:44.454	−57:38:31.55	ON7	V	((f))	...
THA 35-II-42	GOS 284.52−00.24_01	10:25:56.505	−57:48:43.50	O2	I	f*/WN5	...
HD 89 625	GOS 284.81−02.37_01	10:18:58.251	−59:46:04.30	ON9.2	IV	n	...
2MASS J10224377-5930182	GOS 285.06−01.89_01	10:22:43.774	−59:30:18.22	O8	V	(n)	...
2MASS J10224096-5930305	GOS 285.06−01.90_01	10:22:40.961	−59:30:30.58	O7	V	((f))z	...
ALS 18 551	GOS 289.73−01.26_01	10:58:17.678	−61:12:03.48	O4.5	V	(n)z	O4.5 V(n)z
2MASS J10584671-6105512	GOS 289.74−01.14_01	10:58:46.716	−61:05:51.22	O8	Iab	f	...
ALS 18 553	GOS 289.74−01.18_01	10:58:37.773	−61:08:00.35	O6	II	(f)	...
2MASS J10583238-6110565	GOS 289.75−01.23_01	10:58:32.389	−61:10:56.50	O5	V	((f))	O7 V((f))
THA 35-II-153	GOS 289.79−01.18_01	10:59:00.805	−61:08:50.24	O3.5	I	f*/WN7	...
HD 97 966	GOS 290.96+01.20_01	11:15:11.779	−59:24:58.28	O7	V	((f))z	...
HD 97 319	GOS 291.12−00.57_01	11:11:06.156	−61:07:04.56	O7.5	IV	((f))	...
EM Car	GOS 291.22−00.50_01	11:12:04.503	−61:05:42.94	O7.5	V	((f))	O7.5 V((f))
NGC 3603 HST-51	GOS 291.62−00.52_15	11:15:07.498	−61:15:46.35	O5.5	V	(n)	...
NGC 3603 HST-48	GOS 291.62−00.53_02	11:15:08.712	−61:15:59.95	O3.5	I	f*	...
NGC 3603 HST-24	GOS 291.62−00.53_03	11:15:09.353	−61:16:02.07	O4	IV	(f)	...
NGC 3603 MTT 25	GOS 291.63−00.52_01	11:15:11.317	−61:15:55.63	O5	V	(n)	...
HD 99 546	GOS 292.33+01.68_01	11:26:36.905	−59:26:13.61	O7.5	V	((f)) Nstr	...
HD 110 360	GOS 301.80+02.20_01	12:42:12.700	−60:39:08.71	ON7	V	...	...
CPD -61 3973	GOS 309.13−00.20_01	13:45:21.103	−62:25:35.37	O7.5	V	((f))	...
HD 122 313	GOS 311.18−00.54_01	14:03:12.987	−62:15:38.60	O8.5	V	...	...
ALS 17 591	GOS 320.32−01.16_01	15:13:55.206	−59:07:51.61	O5:	...	n(f)p	...
ALS 3386	GOS 326.31+00.74_01	15:42:12.037	−54:11:21.27	O6	Ia	f	...
ALS 18 049	GOS 326.73+00.77_01	15:44:20.206	−53:54:41.31	O9	V	...	...
Muzzio III-9	GOS 327.39−00.62_01	15:53:48.597	−54:35:10.64	O8	Ib	(f)	...
HD 145 217	GOS 332.29+00.77_01	16:12:00.298	−50:18:20.48	O8	V	...	...
HD 144 647	GOS 332.45+01.58_01	16:09:16.197	−49:36:21.75	O8.5	V	(n)	...
HDE 328 209 AB	GOS 338.49+02.85_01	16:29:19.165	−44:28:14.27	ON9	Ib-Ia	p	...
HDE 329 100 A	GOS 340.86−01.05_01	16:54:42.304	−45:15:14.80	O8	V	(n)	...
HDE 326 775	GOS 345.01−00.30_01	17:05:31.316	−41:31:20.12	O6.5	V	(n)((f))z	...
ALS 18 769	GOS 348.67−00.79_01	17:18:53.372	−38:51:13.23	O6	II	(f)	...
HDE 323 110	GOS 349.65−00.67_01	17:21:15.794	−37:59:09.58	ON9	Ia	...	...
Tyc 7370-00460-1	GOS 352.57+02.11_01	17:18:15.396	−34:00:05.94	O6	V	((f))	O8 V
ALS 19 693	GOS 353.07+00.64_01	17:25:29.167	−34:25:15.74	O6	V	n((f))	...
Pismis 24-15	GOS 353.10+00.91_01	17:24:28.952	−34:14:50.68	O7.5	V	z	...
ALS 19 692	GOS 353.11+00.65_01	17:25:34.213	−34:23:11.68	O5.5	IV	(f)	...

NOTE.—*GOSSS ID* is the identification for each star with “GOS” standing for “Galactic O Star”.

TABLE 6  
SPECTRAL CLASSIFICATIONS FOR LATE-TYPE STARS ERRONEOUSLY CLASSIFIED AS O STARS.

Name	RA (J2000)	dec (J2000)	Simbad	GOSSS	Ref.	Fixed?	Comment
ALS 18 890	19:35:23.587	−16:19:46.78	O+...	F	None	No	
Tyc 0468-02112-1	19:16:44.466	+02:28:41.60	O...	F	None	Yes	Currently K86 given as reference for an F? spectral type.
BD +01 3974	19:22:01.484	+02:12:01.90	O	F	K86	No	
HDE 226 144	19:50:59.376	+36:00:03.24	O9 V	A	M80	No	
BD +37 3929	20:25:20.022	+37:42:23.25	O8f	F	H56	No	Confusion with BD +37 3927.
BD +40 4213	20:31:46.006	+41:17:27.07	O9.5 I	F	M91	No	Not in the original reference, likely transcription error in SIMBAD.
BD +45 4132 A	23:04:14.816	+46:36:33.63	O	F	None	Yes	
BD +32 4642 A	23:25:38.697	+33:26:16.94	O	F	None	Yes	
BD +61 100 AB	00:30:32.445	+62:34:00.93	O/B2	G	R89	No	A different reference is given now but the link is broken.
BD -03 2178	08:02:10.340	−04:01:36.39	O5	K	M76	Yes	Confusion with BD -03 2179, a sdO.
CPD −61 4623	14:35:36.520	−61:34:12.77	O	K	None	Yes	

References. — B60:Brodsкая (1960), H56:Hiltner & Johnson (1956), K86:Kelly & Kilkenny (1986), M76: MacConnell & Bidelman (1976), M80:Mikolajewska & Mikolajewski (1980), M91:Massey & Thompson (1991), R89:Radoslavova (1989)